US009348515B2

(12) **United States Patent**
Kaneko et al.

(10) **Patent No.: US 9,348,515 B2**
(45) **Date of Patent: May 24, 2016**

(54) **COMPUTER SYSTEM, MANAGEMENT COMPUTER AND STORAGE MANAGEMENT METHOD FOR MANAGING DATA CONFIGURATION BASED ON STATISTICAL INFORMATION**

(75) Inventors: **Satoshi Kaneko**, Sagamihara (JP); **Akira Yamamoto**, Sagamihara (JP); **Tsukasa Shibayama**, Kawasaki (JP)

(73) Assignee: **Hitachi, Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 299 days.

(21) Appl. No.: **13/139,664**

(22) PCT Filed: **Mar. 22, 2011**

(86) PCT No.: **PCT/JP2011/001680**

§ 371 (c)(1), (2), (4) Date: **Jun. 14, 2011**

(87) PCT Pub. No.: **WO2012/098591**

PCT Pub. Date: **Jul. 26, 2012**

(65) **Prior Publication Data**

US 2012/0185644 A1 Jul. 19, 2012

(30) **Foreign Application Priority Data**

Jan. 17, 2011 (JP) 2011-007260

(51) **Int. Cl.**

G06F 12/00 (2006.01)
G06F 12/02 (2006.01)
G06F 3/06 (2006.01)

(52) **U.S. Cl.**

CPC ***G06F 3/061*** (2013.01); ***G06F 3/067*** (2013.01); ***G06F 3/0647*** (2013.01); ***G06F 3/0653*** (2013.01)

(58) **Field of Classification Search**

CPC ... G06F 3/0647; G06F 3/0635; G06F 3/0689; G06F 3/0631; G06F 3/061; G06F 3/0613; G06F 2211/1028; G06F 2211/1057; G06F 3/0608; G06F 3/0653; G06F 3/0626; G06F 3/0644; G06F 8/71; G06F 11/203; G06F 3/0604

USPC 711/114, E12.001, E12.002, 154, 170, 711/165

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,627,731 B2 * 12/2009 Sugino et al. 711/170
8,065,431 B2 * 11/2011 Taylor et al. 709/236

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2007-280089 A 10/2007
JP 2008-047156 2/2008

(Continued)

OTHER PUBLICATIONS

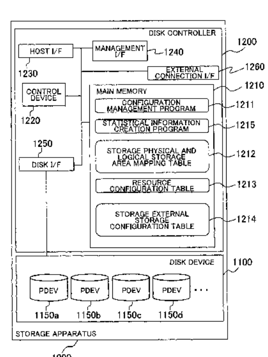
PCT International Search Report and Written Opinion on application No. PCT/JP2011/001680 dated May 17, 2011; 10 pages.

Primary Examiner — Yong Choe
Assistant Examiner — Edward Waddy, Jr.
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

A storage apparatus comprises a storage device storing data which is read/written by a host computer and a control device for controlling data writing to the storage device. The control device provides a predetermined storage area of the storage device to the host computer as one or more volumes and, in response to the request from the management computer, provides statistical information relating to the storage areas to the management computer. the management computer comprises a storage device storing a storage area management table for managing the storage area of a plurality of storage apparatuses and a control device for managing the configuration of the storage areas of the storage apparatuses. The control device manages the data configuration of the plurality of storage apparatuses on the basis of the statistical information relating to the storage areas of the storage apparatuses which is provided by the plurality of storage apparatuses.

8 Claims, 19 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

8,407,417	B2 *	3/2013	Matsuda et al.	711/114
2006/0026373	A1 *	2/2006	Kaneda et al.	711/162
2006/0155928	A1 *	7/2006	Mimatsu	G06F 3/0607 711/112
2007/0113007	A1 *	5/2007	Murayama et al.	711/114
2007/0118710	A1 *	5/2007	Yamakawa	G06F 3/061 711/165
2007/0130423	A1 *	6/2007	Liu et al.	711/114
2007/0162716	A1 *	7/2007	Yagisawa	G06F 11/1435 711/162
2007/0239954	A1 *	10/2007	Sakashita	G06F 3/061 711/165
2008/0028049	A1 *	1/2008	Taguchi et al.	709/220
2008/0091898	A1	4/2008	Takahashi et al.	
2008/0104339	A1 *	5/2008	Nakagawa et al.	711/154
2008/0104350	A1 *	5/2008	Shimizu	G06F 3/0605 711/165
2008/0104443	A1	5/2008	Akutsu et al.	
2008/0201544	A1 *	8/2008	Nakajima et al.	711/166
2009/0182930	A1 *	7/2009	Taguchi et al.	711/100
2009/0248759	A1 *	10/2009	Okada et al.	707/204
2009/0265511	A1 *	10/2009	Fujita	G06F 3/0607 711/114
2009/0292870	A1 *	11/2009	Sambe et al.	711/114
2009/0300283	A1 *	12/2009	Kudo	G06F 3/061 711/114
2009/0307422	A1 *	12/2009	Galloway	G06F 11/1076 711/114
2010/0049917	A1 *	2/2010	Kono et al.	711/114
2010/0211949	A1	8/2010	Nakajima et al.	
2010/0235604	A1 *	9/2010	Oe et al.	711/170
2010/0325378	A1	12/2010	Maruyama et al.	
2010/0332882	A1 *	12/2010	Nayak	G06F 3/0625 713/324
2011/0264855	A1 *	10/2011	Kasako	711/114
2012/0102350	A1 *	4/2012	Belluomini et al.	713/324
2012/0198151	A1 *	8/2012	Kato et al.	711/114

FOREIGN PATENT DOCUMENTS

JP	2008-134987 A	6/2008
JP	2008-203937	9/2008
JP	2010-191524 A	9/2010

* cited by examiner

FIG. 1

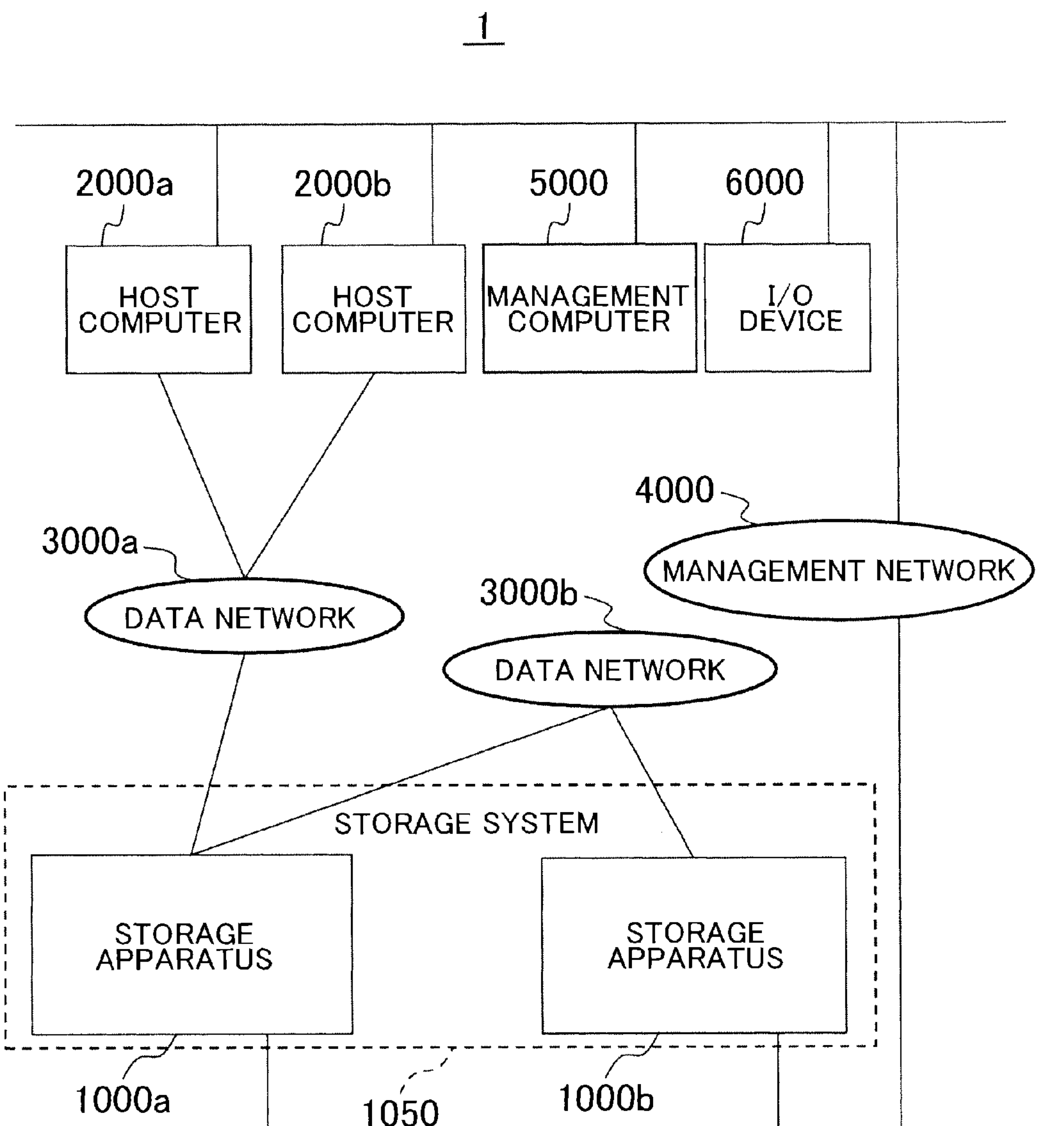

1
2000a
2000b
5000
6000
HOST COMPUTER
HOST COMPUTER
MANAGEMENT COMPUTER
I/O DEVICE
4000
MANAGEMENT NETWORK
3000a
DATA NETWORK
3000b
DATA NETWORK
STORAGE SYSTEM
STORAGE APPARATUS
STORAGE APPARATUS
1000a
1050
1000b

FIG. 2

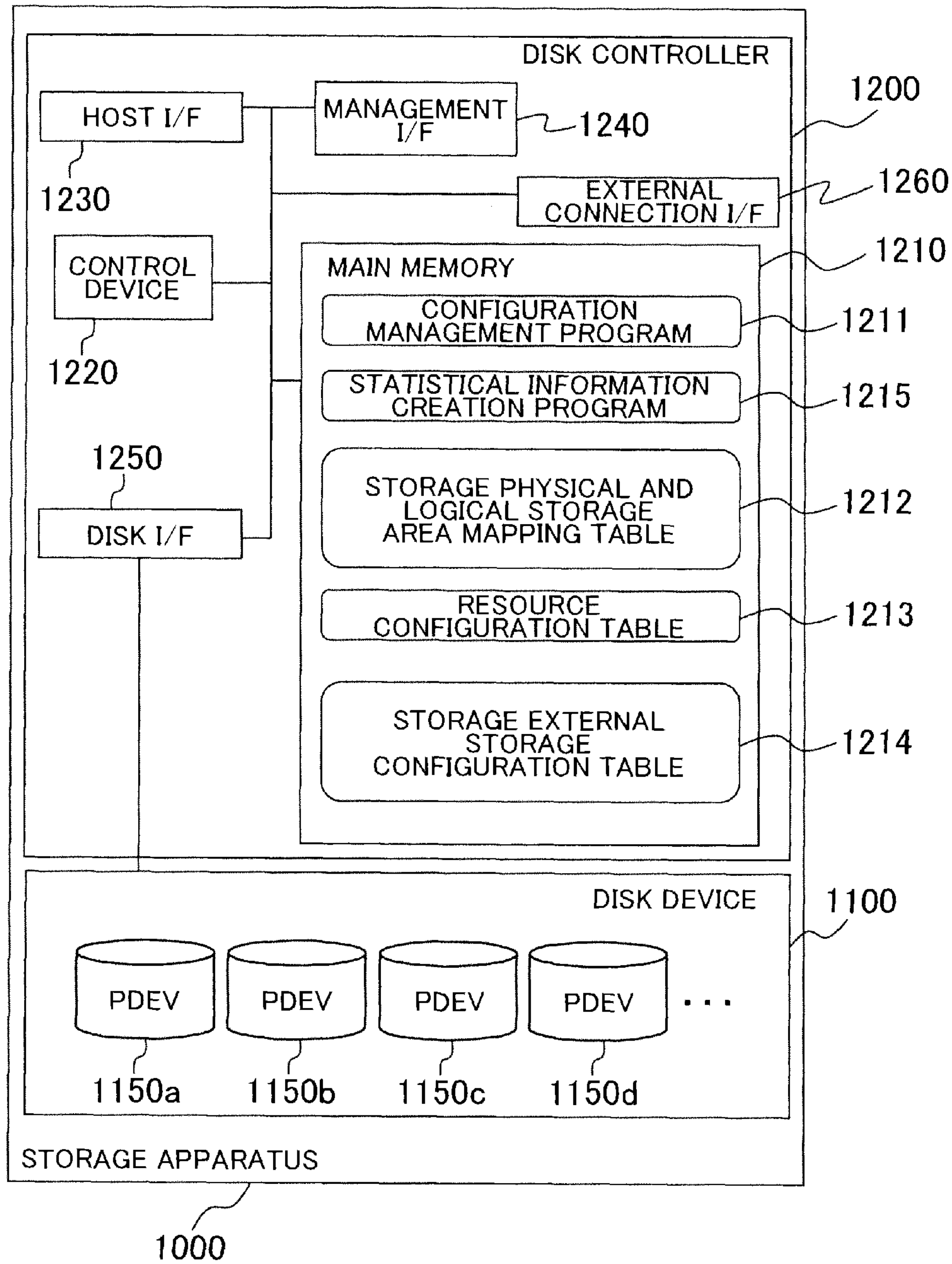

DISK CONTROLLER
1200
HOST I/F
MANAGEMENT I/F
1240
1230
EXTERNAL CONNECTION I/F
1260
MAIN MEMORY
1210
CONTROL DEVICE
CONFIGURATION MANAGEMENT PROGRAM
1211
1220
STATISTICAL INFORMATION CREATION PROGRAM
1215
1250
STORAGE PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE
1212
DISK I/F
RESOURCE CONFIGURATION TABLE
1213
STORAGE EXTERNAL STORAGE CONFIGURATION TABLE
1214
DISK DEVICE
1100
PDEV
PDEV
PDEV
PDEV
1150a
1150b
1150c
1150d
STORAGE APPARATUS
1000

FIG. 3

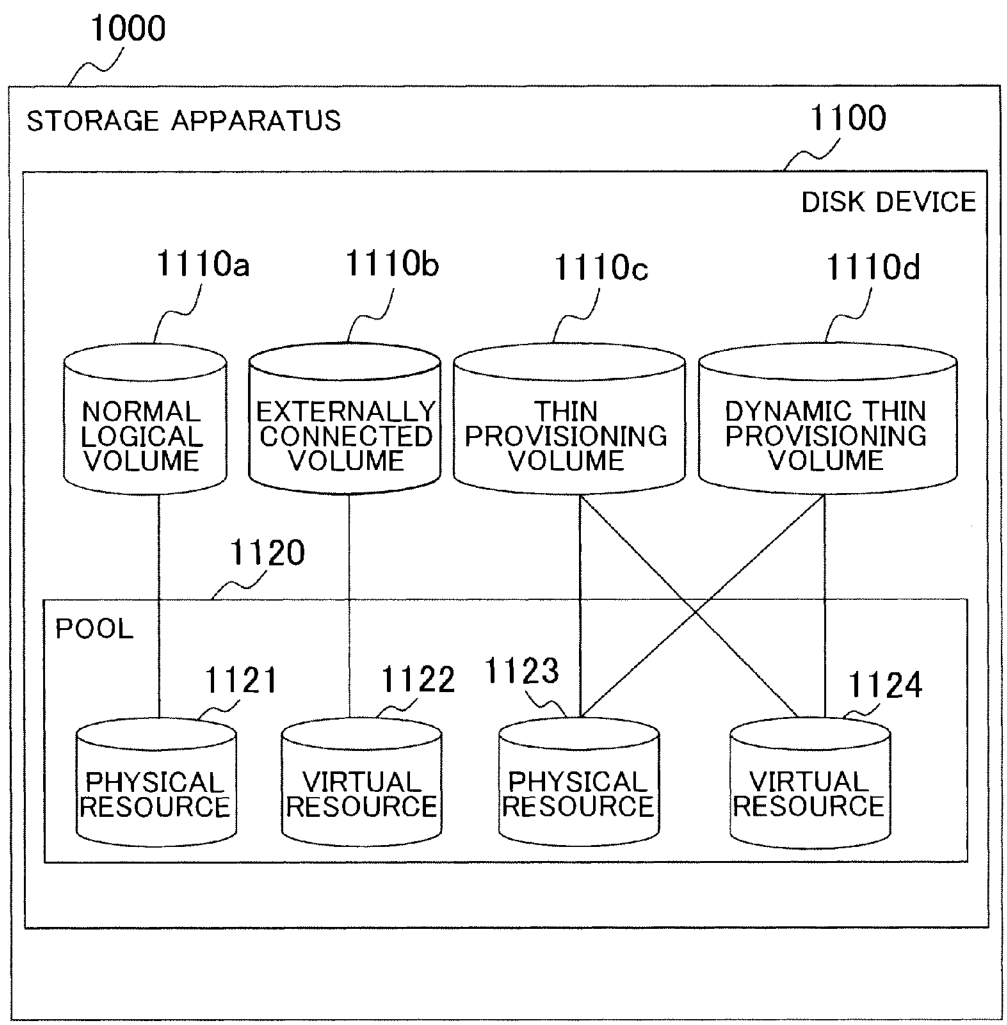

1000
STORAGE APPARATUS
1100
DISK DEVICE
1110a
1110b
1110c
1110d
NORMAL LOGICAL VOLUME
EXTERNALLY CONNECTED VOLUME
THIN PROVISIONING VOLUME
DYNAMIC THIN PROVISIONING VOLUME
1120
POOL
1121
1122
1123
1124
PHYSICAL RESOURCE
VIRTUAL RESOURCE
PHYSICAL RESOURCE
VIRTUAL RESOURCE

FIG. 4

1212

VOLUME IDENTIFIER	LOGICAL START ADDRESS	LOGICAL END ADDRESS	POOL IDENTIFIER	RESOURCE IDENTIFIER	PHYSICAL START ADDRESS	PHYSICAL END ADDRESS
0	0	999	1	0	1000	1999
	1000	1999		1	0	999
	2000	2999		2	0	999
	3000	3999		2	1000	2999
	4000	199999		null	null	null
⋮	⋮	⋮	⋮	⋮	⋮	⋮
12120	12121	12122	12123	12124	12125	12126

FIG. 5

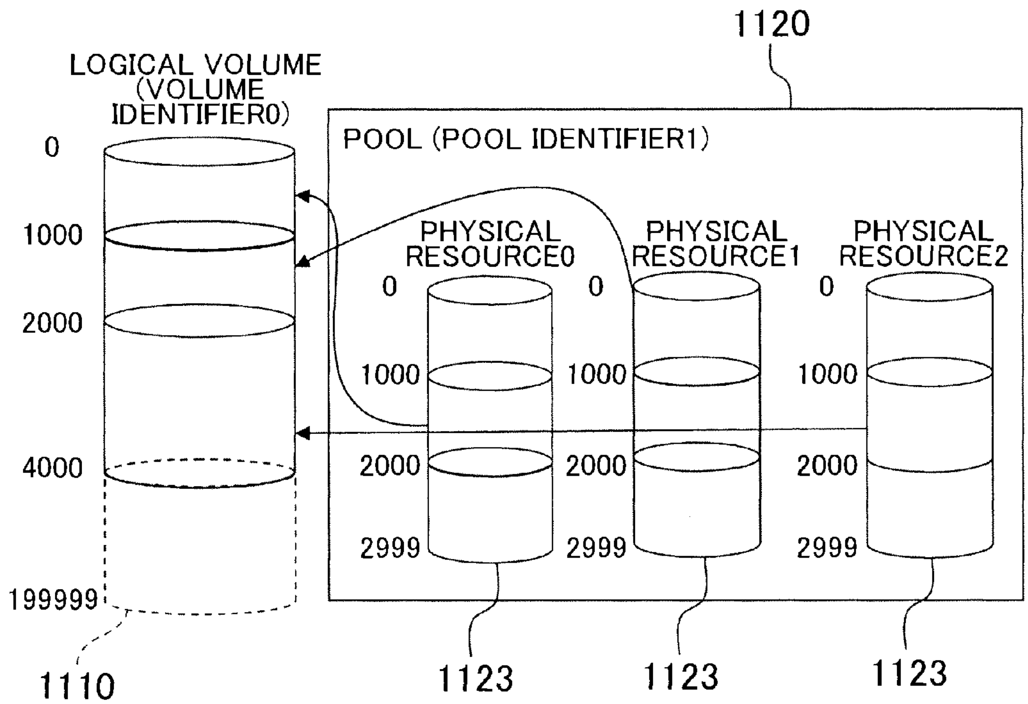

1120
LOGICAL VOLUME (VOLUME IDENTIFIER0)
POOL (POOL IDENTIFIER1)
PHYSICAL RESOURCE0
PHYSICAL RESOURCE1
PHYSICAL RESOURCE2
0
1000
2000
4000
199999
2999
1110
1123
1123
1123

FIG. 6

POOL IDENTIFIER	RESOURCE IDENTIFIER	RESOURCE TYPE	RESOURCE CONFIGURATION
0	0	FC	INTERNAL
	1	FC	INTERNAL
	2	SSD	INTERNAL
1	3	FC	EXTERNAL

12130 12131 12132 12133

1213

FIG. 7

RESOURCE IDENTIFIER	PORT IDENTIFIER	EXTERNAL STORAGE IDENTIFIER	EXTERNAL STORAGE RESOURCE IDENTIFIER	EXTERNAL STORAGE PORT IDENTIFIER
3	0	STORAGE2	0	1
⋮	⋮	⋮	⋮	⋮

12140 12141 12142 12143 12144

1214

FIG. 8

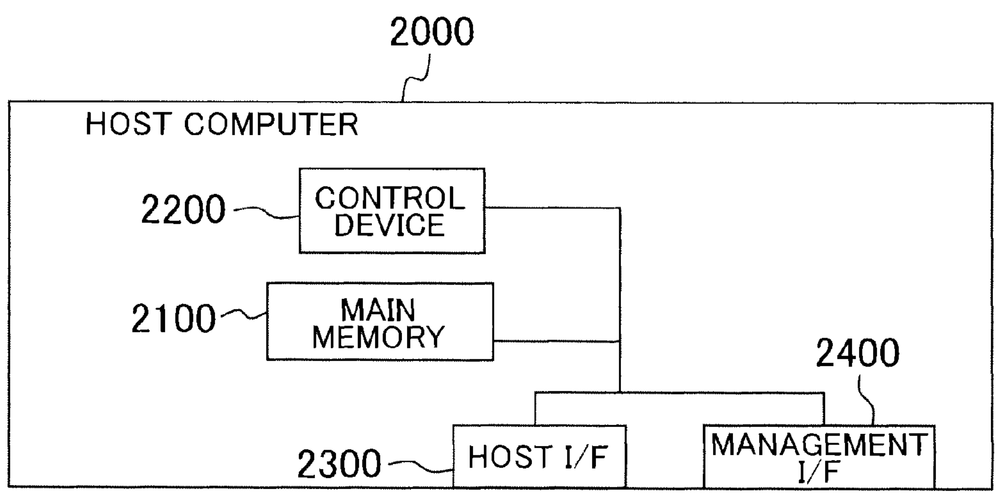

2000
HOST COMPUTER
2200
CONTROL DEVICE
2100
MAIN MEMORY
2400
2300
HOST I/F
MANAGEMENT I/F

FIG. 9

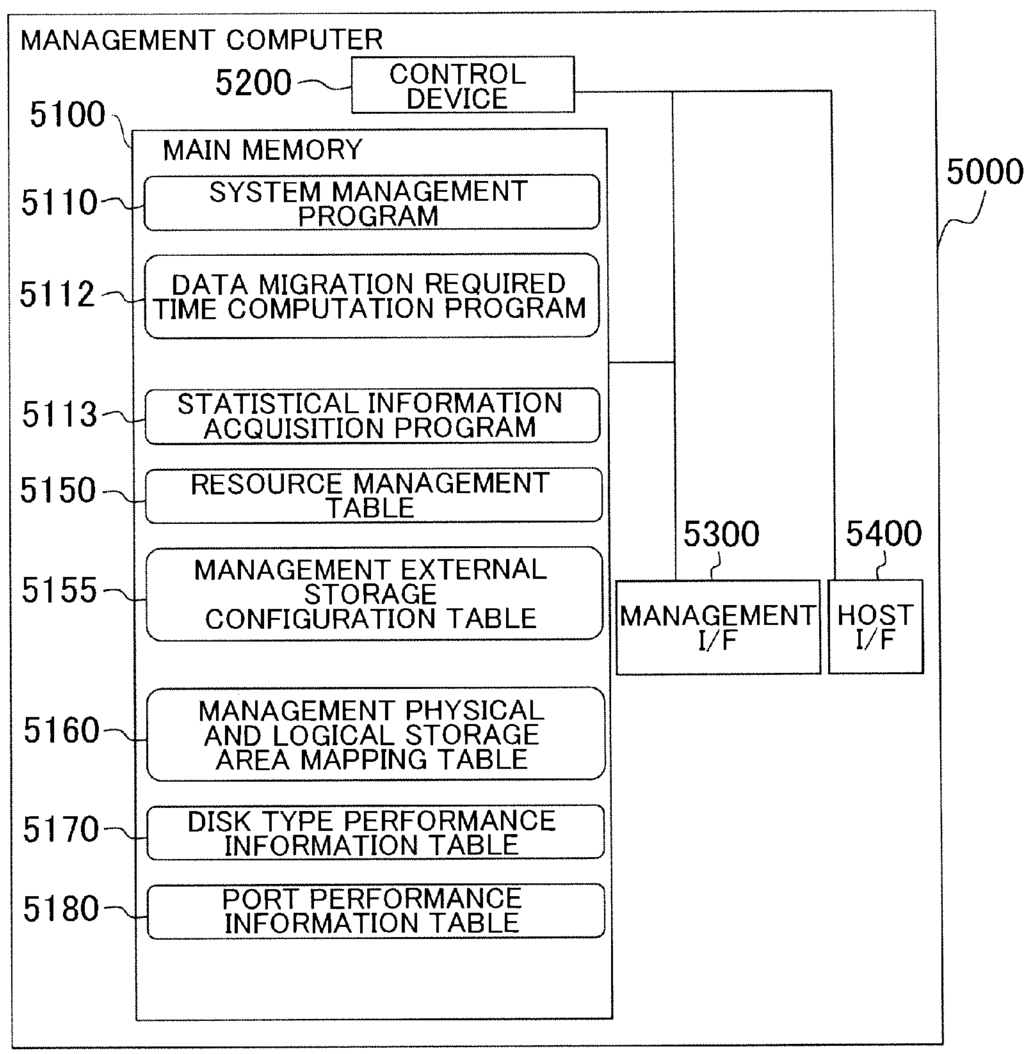

MANAGEMENT COMPUTER
5200
CONTROL DEVICE
5100
MAIN MEMORY
5110
SYSTEM MANAGEMENT PROGRAM
5112
DATA MIGRATION REQUIRED TIME COMPUTATION PROGRAM
5113
STATISTICAL INFORMATION ACQUISITION PROGRAM
5150
RESOURCE MANAGEMENT TABLE
5155
MANAGEMENT EXTERNAL STORAGE CONFIGURATION TABLE
5160
MANAGEMENT PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE
5170
DISK TYPE PERFORMANCE INFORMATION TABLE
5180
PORT PERFORMANCE INFORMATION TABLE
5000
5300
MANAGEMENT I/F
5400
HOST I/F

FIG. 10

5150

APPARATUS IDENTIFIER 51500	POOL IDENTIFIER 51501	RESOURCE IDENTIFIER 51502	RESOURCE TYPE 51503	RESOURCE CONFIGURATION 51504
STRAGE1	0	0	FC	INTERNAL
	1	1	FC	INTERNAL
		2	SSD	INTERNAL
		3	FC	EXTERNAL
	2	4	SATA	EXTERNAL
⋮	⋮	⋮	⋮	⋮

FIG. 11

5155

STORAGE IDENTIFIER 51550	RESOURCE IDENTIFIER 51551	PORT IDENTIFIER 51552	EXTERNAL STORAGE IDENTIFIER 51553	EXTERNAL STORAGE RESOURCE IDENTIFIER 51554	EXTERNAL STORAGE PORT IDENTIFIER 51555
STRAGE1	3	0	STRAGE2	0	1
	4	1	STRAGE2	1	2
⋮	⋮	⋮	⋮	⋮	⋮

FIG. 12

APPARATUS IDENTIFIER	VOLUME IDENTIFIER	POOL IDENTIFIER	RESOURCE IDENTIFIER	ASSIGNED SEGMENT COUNT
STRAGE1	0	1	1	1000
			2	1000
			3	2000
⋮	⋮	⋮	⋮	⋮

5160

51600 51601 51602 51603 51604

FIG. 13

APPARATUS IDENTIFIER	RESOURCE TYPE	READ PERFORMANCE (G/sec)	WRITE PERFORMANCE (G/sec)
STRAGE1	SSD	10	5
	FC	8	4
	SATA	3	1
⋮	⋮	⋮	⋮

5170

51700 51701 51702 51703

FIG. 14

5180

APPARATUS IDENTIFIER	PORT IDENTIFIER	MAXIMUM IOPS (G/sec)
STRAGE1	0	10
	1	8
	2	3
⋮	⋮	⋮
51800	51801	51802

FIG. 15

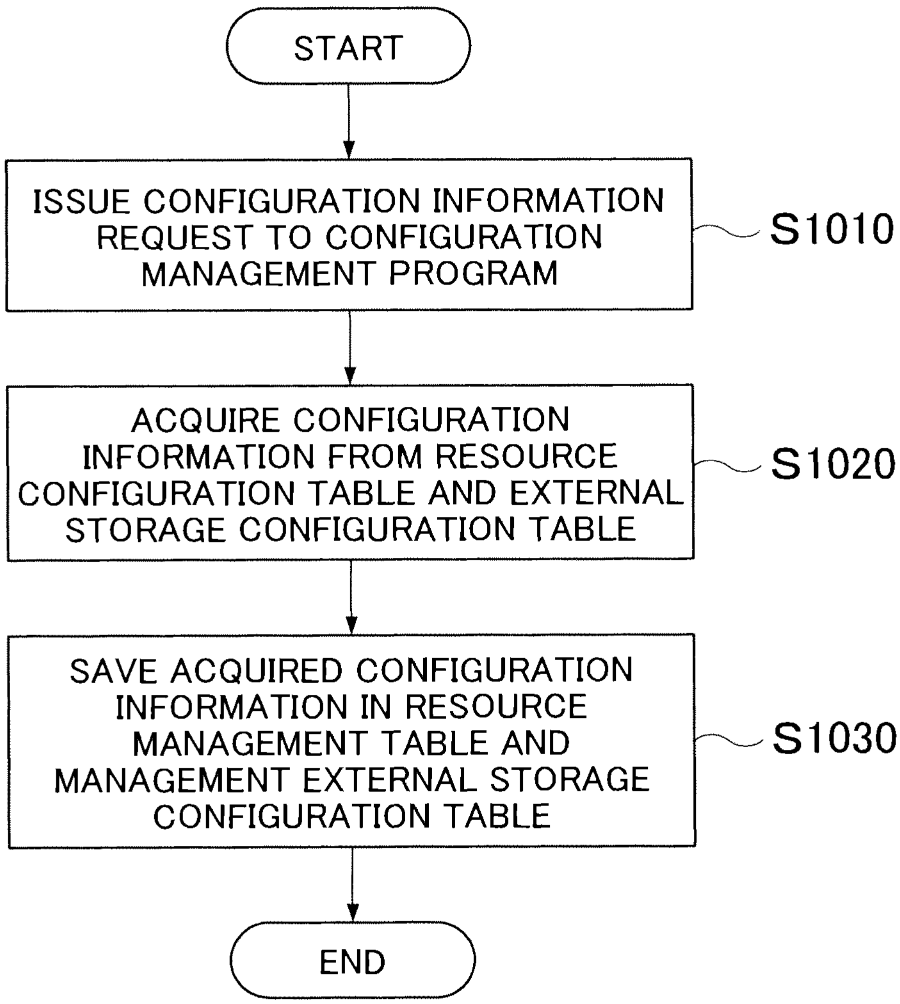

START
ISSUE CONFIGURATION INFORMATION REQUEST TO CONFIGURATION MANAGEMENT PROGRAM
S1010
ACQUIRE CONFIGURATION INFORMATION FROM RESOURCE CONFIGURATION TABLE AND EXTERNAL STORAGE CONFIGURATION TABLE
S1020
SAVE ACQUIRED CONFIGURATION INFORMATION IN RESOURCE MANAGEMENT TABLE AND MANAGEMENT EXTERNAL STORAGE CONFIGURATION TABLE
S1030
END

FIG. 16

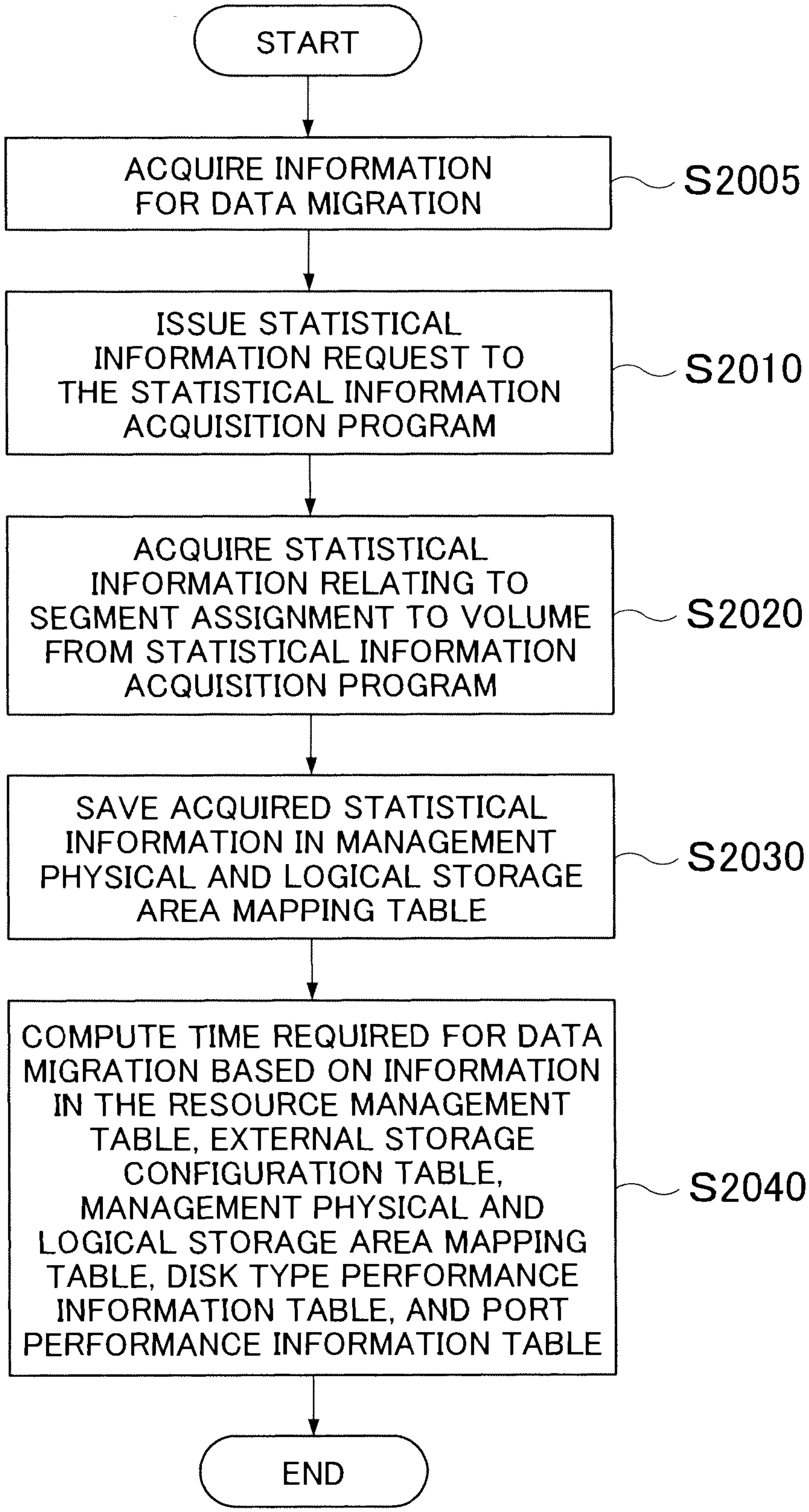

START
ACQUIRE INFORMATION FOR DATA MIGRATION
S2005
ISSUE STATISTICAL INFORMATION REQUEST TO THE STATISTICAL INFORMATION ACQUISITION PROGRAM
S2010
ACQUIRE STATISTICAL INFORMATION RELATING TO SEGMENT ASSIGNMENT TO VOLUME FROM STATISTICAL INFORMATION ACQUISITION PROGRAM
S2020
SAVE ACQUIRED STATISTICAL INFORMATION IN MANAGEMENT PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE
S2030
COMPUTE TIME REQUIRED FOR DATA MIGRATION BASED ON INFORMATION IN THE RESOURCE MANAGEMENT TABLE, EXTERNAL STORAGE CONFIGURATION TABLE, MANAGEMENT PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE, DISK TYPE PERFORMANCE INFORMATION TABLE, AND PORT PERFORMANCE INFORMATION TABLE
S2040
END

FIG. 17

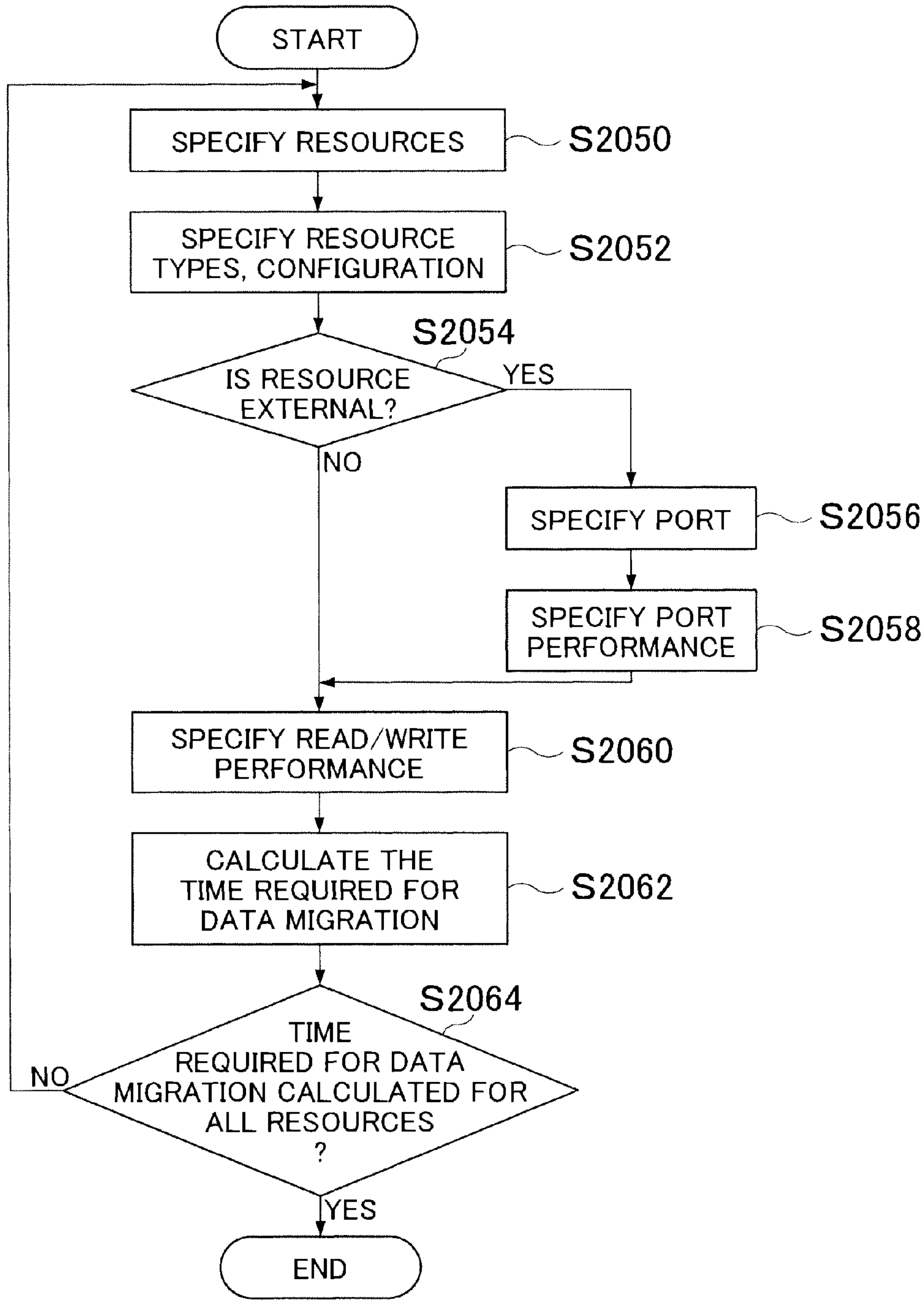

START
SPECIFY RESOURCES
S2050
SPECIFY RESOURCE TYPES, CONFIGURATION
S2052
S2054
IS RESOURCE EXTERNAL?
YES
NO
SPECIFY PORT
S2056
SPECIFY PORT PERFORMANCE
S2058
SPECIFY READ/WRITE PERFORMANCE
S2060
CALCULATE THE TIME REQUIRED FOR DATA MIGRATION
S2062
S2064
TIME REQUIRED FOR DATA MIGRATION CALCULATED FOR ALL RESOURCES ?
NO
YES
END

FIG. 18

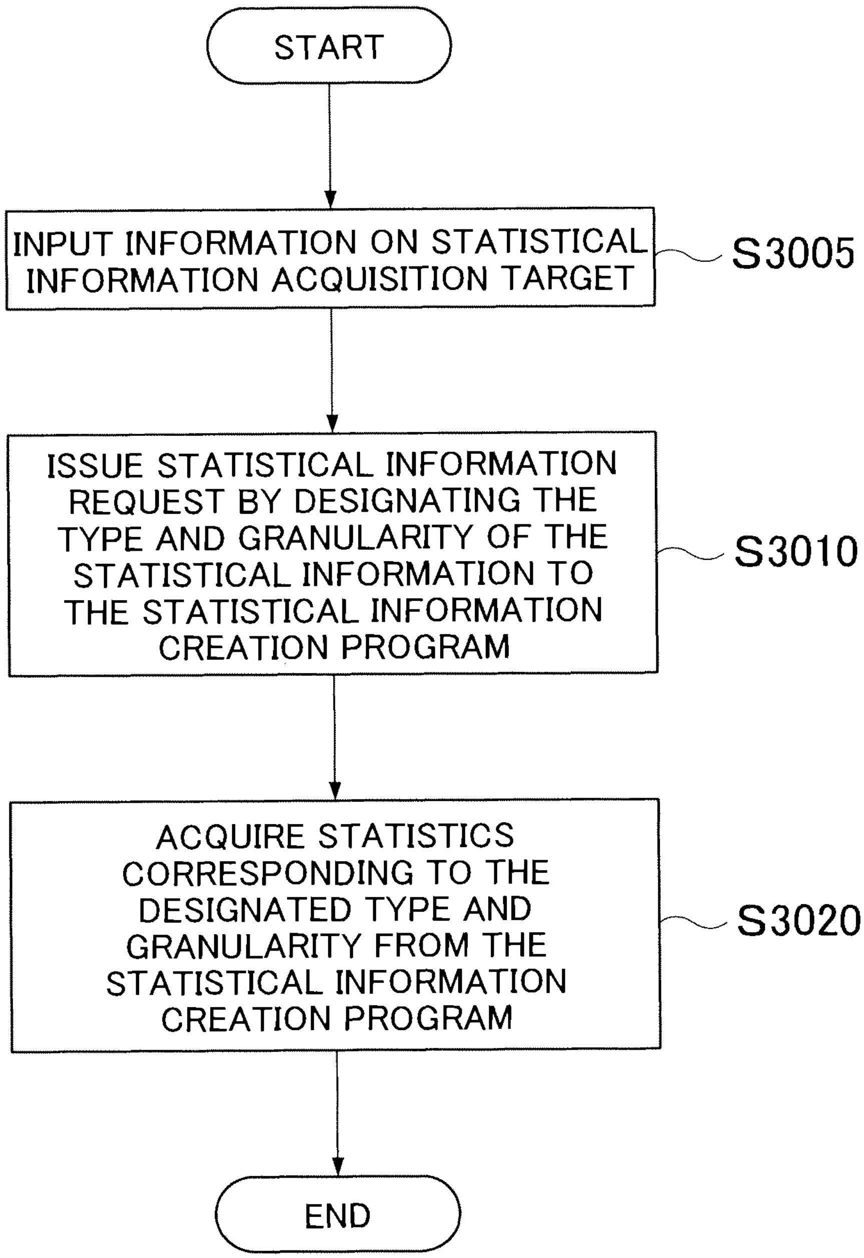
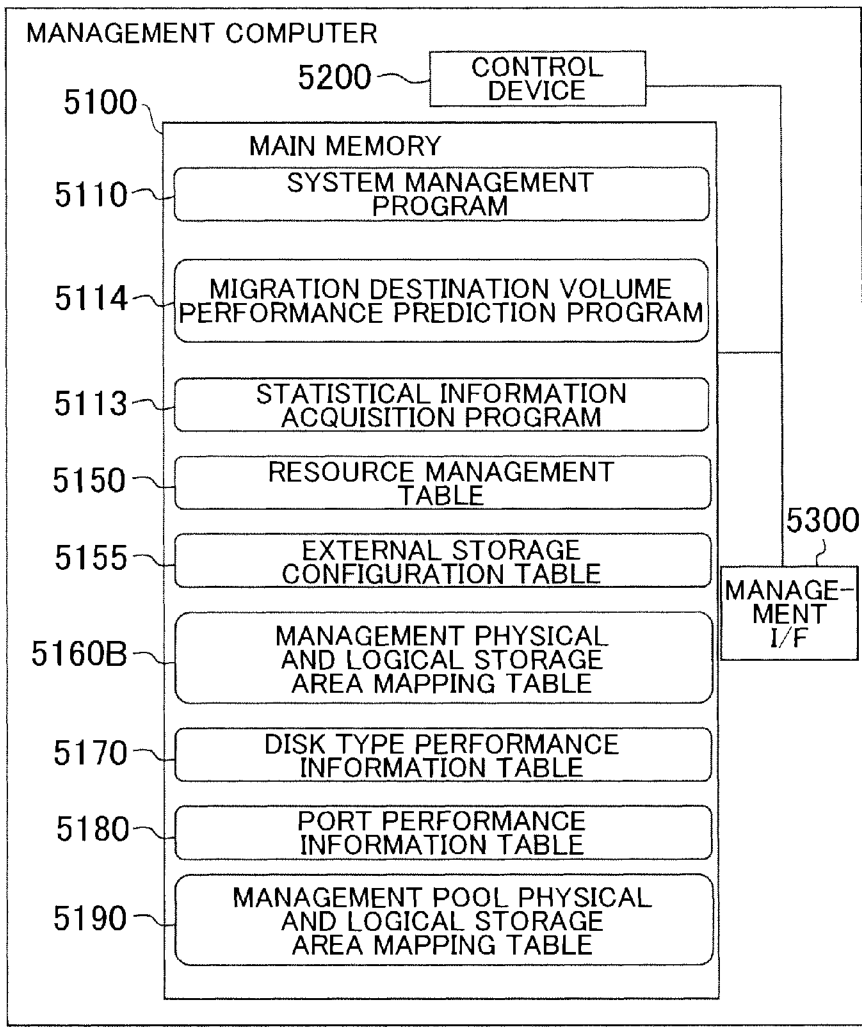

START
INPUT INFORMATION ON STATISTICAL INFORMATION ACQUISITION TARGET
S3005
ISSUE STATISTICAL INFORMATION REQUEST BY DESIGNATING THE TYPE AND GRANULARITY OF THE STATISTICAL INFORMATION TO THE STATISTICAL INFORMATION CREATION PROGRAM
S3010
ACQUIRE STATISTICS CORRESPONDING TO THE DESIGNATED TYPE AND GRANULARITY FROM THE STATISTICAL INFORMATION CREATION PROGRAM
S3020
END

FIG. 19



MANAGEMENT COMPUTER
5200
CONTROL DEVICE
5100
MAIN MEMORY
5000
5110
SYSTEM MANAGEMENT PROGRAM
5114
MIGRATION DESTINATION VOLUME PERFORMANCE PREDICTION PROGRAM
5113
STATISTICAL INFORMATION ACQUISITION PROGRAM
5150
RESOURCE MANAGEMENT TABLE
5300
5155
EXTERNAL STORAGE CONFIGURATION TABLE
MANAGE-MENT I/F
5160B
MANAGEMENT PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE
5170
DISK TYPE PERFORMANCE INFORMATION TABLE
5180
PORT PERFORMANCE INFORMATION TABLE
5190
MANAGEMENT POOL PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE

FIG. 20

APPARATUS IDENTIFIER	VOLUME IDENTIFIER	POOL IDENTIFIER	RESOURCE IDENTIFIER	ASSIGNED SEGMENT COUNT	AVERAGE IOPS
STRAGE1	0	1	1	1000	6000
			2	1000	5000
			3	2000	3000
⋮	⋮	⋮	⋮	⋮	⋮
51600	51601	51602	51603	51604	51605

5160B

FIG. 21

APPARATUS IDENTIFIER	POOL IDENTIFIER	RESOURCE IDENTIFIER	TOTAL NUMBER OF SEGMENTS	ASSIGNED SEGMENT COUNT	AVERAGE IOPS TO ASSIGNED SEGMENTS
STRAGE1	1	10	1000	1000	4000
		11	1000	1000	3000
		12	8000	2000	2500
⋮	⋮	⋮	⋮	⋮	⋮
51900	51901	51902	51903	51904	51905

5190

FIG. 22

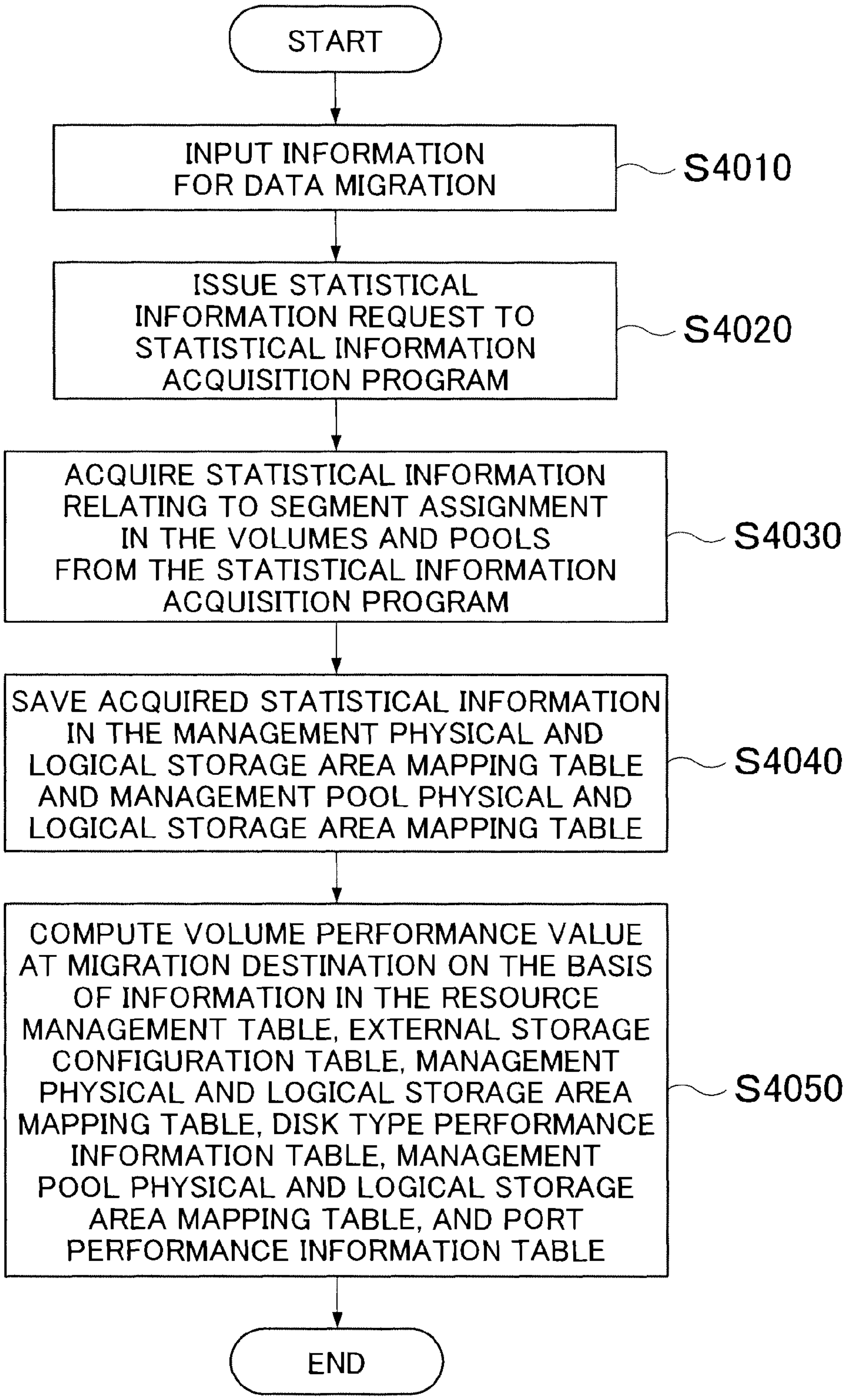
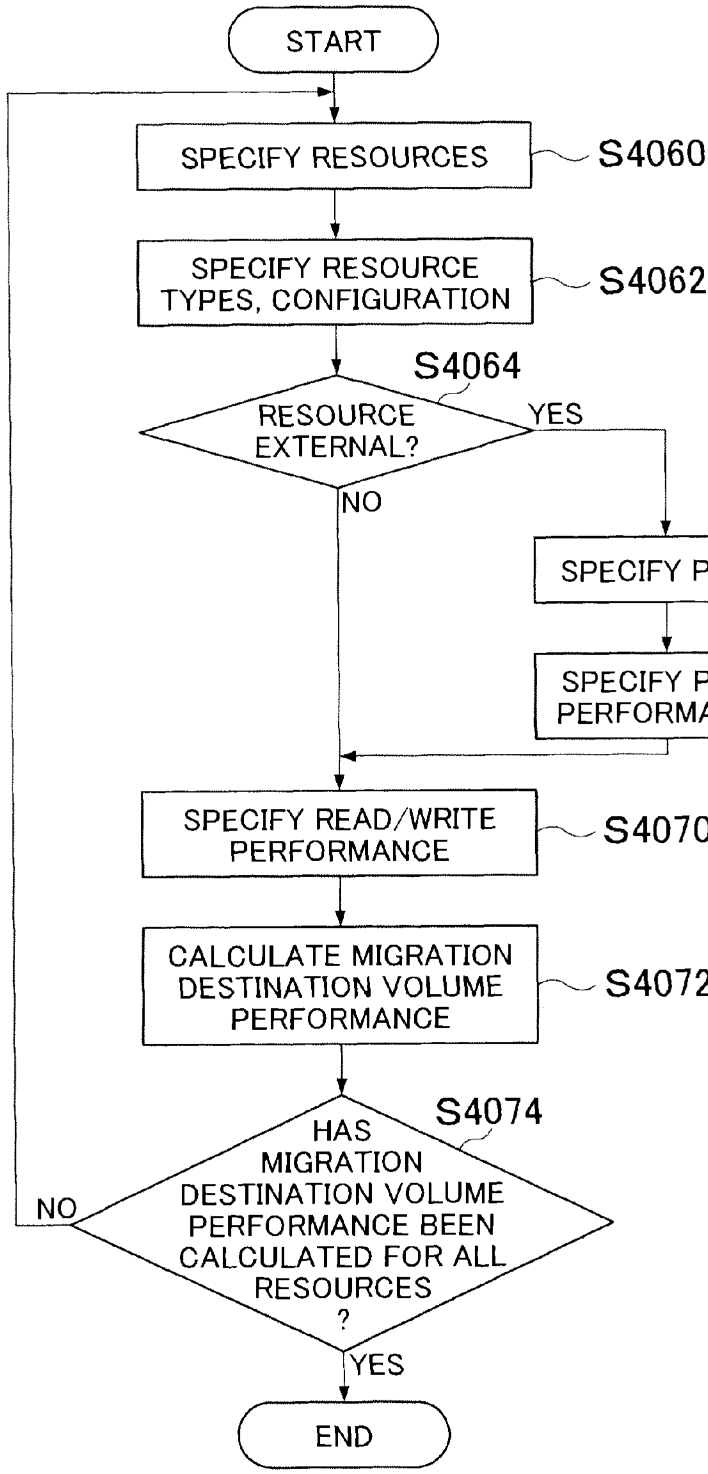

START
INPUT INFORMATION FOR DATA MIGRATION
S4010
ISSUE STATISTICAL INFORMATION REQUEST TO STATISTICAL INFORMATION ACQUISITION PROGRAM
S4020
ACQUIRE STATISTICAL INFORMATION RELATING TO SEGMENT ASSIGNMENT IN THE VOLUMES AND POOLS FROM THE STATISTICAL INFORMATION ACQUISITION PROGRAM
S4030
SAVE ACQUIRED STATISTICAL INFORMATION IN THE MANAGEMENT PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE AND MANAGEMENT POOL PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE
S4040
COMPUTE VOLUME PERFORMANCE VALUE AT MIGRATION DESTINATION ON THE BASIS OF INFORMATION IN THE RESOURCE MANAGEMENT TABLE, EXTERNAL STORAGE CONFIGURATION TABLE, MANAGEMENT PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE, DISK TYPE PERFORMANCE INFORMATION TABLE, MANAGEMENT INFORMATION TABLE, MANAGEMENT POOL PHYSICAL AND LOGICAL STORAGE AREA MAPPING TABLE, AND PORT PERFORMANCE INFORMATION TABLE
S4050
END

FIG. 23


START
SPECIFY RESOURCES
S4060
SPECIFY RESOURCE TYPES, CONFIGURATION
S4062
S4064
RESOURCE EXTERNAL?
YES
NO
SPECIFY PORT
S4066
SPECIFY PORT PERFORMANCE
S4068
SPECIFY READ/WRITE PERFORMANCE
S4070
CALCULATE MIGRATION DESTINATION VOLUME PERFORMANCE
S4072
S4074
HAS MIGRATION DESTINATION VOLUME PERFORMANCE BEEN CALCULATED FOR ALL RESOURCES ?
NO
YES
END

COMPUTER SYSTEM, MANAGEMENT COMPUTER AND STORAGE MANAGEMENT METHOD FOR MANAGING DATA CONFIGURATION BASED ON STATISTICAL INFORMATION

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application is the US national phase application of PCT Application PCT/JP2011/001680 filed Mar. 22, 2011, which claims priority from Japan Application 2011-007260, filed Jan. 17, 2011. All of the aforesaid applications are incorporated herein by reference in their entirety as if fully set forth herein.

TECHNICAL FIELD

The present invention relates to a computer system, a management computer and a storage management method, and is suitably applied to a computer system which manages data migration of a storage apparatus, and to a management computer and storage management method.

BACKGROUND ART

Recent years have witnessed a trend toward year-on-year increases in the amount of data handled by computer systems, and such increases in the amount of data have been handled by adding new storage apparatuses and migrating data between existing storage systems.

The units of the data migrated between storage systems are units of storage areas which are used by the host computer to store data in the storage apparatuses, namely, for example, logical volumes which are configured from a single hard disk drive (HDD), logical volumes in RAID (Redundant Arrays of Independent Disks) groups configured from a plurality of hard disk drives, or virtual logical volumes (hereinafter called 'virtual volumes') utilizing Thin Provisioning, and the like.

Here, Thin Provisioning is a function which provides virtual volumes to a host computer and which, when there is a request from the host computer to write data to a virtual volume, dynamically assigns a physical storage area for storing data to the virtual volume. With such Thin Provisioning, a virtual volume which has a greater capacity than the storage area which is actually available can be provided to the host apparatus. Furthermore, most recently, storage management has been efficiently performed by using hard disk drives of a plurality of types of varying performance. For example, according to a management technique known as hierarchical storage management (HSM), storage area is assigned from a high-speed, high-performance storage tier to an area where data of a high access frequency is stored and storage area is assigned from a low-speed, low-performance storage tier to an area where data of a low access frequency is stored.

Furthermore, PTL1 discloses a technology whereby information of a migration-source storage area in which migrated data is stored and information of a data migration-destination storage area are acquired and whereby the time required to migrate the data is calculated and an optimal data migration plan is created. For example, the migration of data of a high access frequency can be migrated by prioritizing the migration of data stored in a high-performance storage tier over the migration of data stored in a low-performance storage tier.

CITATION LIST

Patent Literature

[PTL 1]
Japanese Published Patent Application No. 2008-203937

SUMMARY OF INVENTION

Technical Problem

However, with PTL1, in order to calculate the time required for data migration, the management computer, which manages a plurality of storage apparatuses, is required to acquire all the information relating to an optional storage area from a storage apparatus serving as a data migration source and a storage apparatus serving as a data migration destination. There is therefore a problem in that the data amount transferred between the management computer and the storage apparatuses is enormous, which is apt to degrade the overall performance of the storage system.

The present invention was devised in view of the aforementioned problems, and seeks to propose a storage system capable of efficiently acquiring information relating to storage areas of a storage apparatus, as well as a management computer and storage management method.

Solution to Problem

In order to achieve the foregoing object, the present invention provides a computer system in which a plurality of storage apparatuses, a plurality of host apparatuses which issue a data writing request to the plurality of storage apparatuses, and a management computer which manages the plurality of storage apparatuses and plurality of host apparatuses are interconnected via a network. The storage apparatus comprises a storage device which stores data which is read/written by the host computer; and a control device which controls the data writing to the storage device, wherein the control device provides a predetermined storage area of the storage device to the host computer as one or more volumes and provides statistical information relating to the storage areas to the management computer in response to a request from the management computer, wherein the management computer comprises a storage device for storing a storage area management table which manages storage areas of the plurality of storage apparatuses, and a control device for managing the configuration of the storage areas of the plurality of storage apparatuses, and wherein the control device manages the data configuration of the plurality of storage apparatuses on the basis of statistical information relating to the storage areas of the storage apparatuses and which is provided by the plurality of storage apparatuses.

According to this configuration, the storage apparatus provides a predetermined storage area of the storage apparatus to the host computer as one or more volumes, the management computer issues a request for the statistical information relating to the storage areas to the storage apparatus, the storage apparatus provides the statistical information relating to the storage areas to the management computer in response to the request from the management computer, and the management computer manages the data configuration of the plurality of storage apparatuses on the basis of the statistical information relating to the storage areas of the storage apparatuses which is provided by the plurality of storage apparatuses. Accordingly, even when not all the information relating to the storage area stored in the storage apparatus is acquired, because the migration time of data stored in the storage apparatus and the data I/O performance at the data migration destination can be calculated by acquiring the statistical information of the storage areas, the amount of transferred data and the transfer time can be greatly shortened.

Advantageous Effects of Invention

The present invention makes it possible to prevent degradation of the overall performance of a storage system by efficiently acquiring information relating to storage areas of storage apparatuses.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram showing the overall configuration of a computer system according to a first embodiment of the present invention.

FIG. **2** is a block diagram showing the configuration of a storage apparatus according to the first embodiment.

FIG. **3** is a block diagram showing the configuration of a disk device according to the first embodiment.

FIG. **4** is a diagram showing an example of a storage physical and logical storage area mapping table according to the first embodiment.

FIG. **5** is a conceptual diagram showing an example of information which is stored in the storage physical and logical storage area mapping table according to the first embodiment.

FIG. **6** is a diagram showing an example of a resource configuration table according to the first embodiment.

FIG. **7** is a diagram showing an example of a storage external storage configuration table according to the first embodiment.

FIG. **8** is a block diagram showing the configuration of a host computer according to the first embodiment.

FIG. **9** is a block diagram showing the configuration of a management computer according to the first embodiment.

FIG. **10** is a diagram showing an example of a resource management table according to the first embodiment.

FIG. **11** is a diagram showing a management external storage configuration table according to the first embodiment.

FIG. **12** is a diagram showing an example of a management physical and logical storage area mapping table according to the first embodiment.

FIG. **13** is a diagram showing an example of a disk type performance information table according to the first embodiment.

FIG. **14** is a diagram showing an example of a port performance information table according to the first embodiment.

FIG. **15** is a flowchart showing a processing routine for processing of a system management program according to the first embodiment.

FIG. **16** is a flowchart showing a processing routine of a data migration required time computation program according to the first embodiment.

FIG. **17** is a flowchart showing a specific example of the data migration required time calculation processing according to the first embodiment.

FIG. **18** is a flowchart showing a processing routine for processing of a statistical information acquisition program according to the first embodiment.

FIG. **19** is a block diagram showing the configuration of a management computer according to a second embodiment of the present invention.

FIG. **20** is a diagram showing an example of a management physical and logical storage area mapping table according to the second embodiment.

FIG. **21** is a diagram showing an example of a management pool physical and logical storage area mapping table according to the second embodiment.

FIG. **22** is a flowchart showing a processing routine for the processing of a migration-destination volume performance prediction program according to the second embodiment.

FIG. **23** is a flowchart showing a specific example of a migration-destination volume performance prediction program according to the second embodiment.

DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will be described in detail hereinbelow with reference to the drawings.

Note that, in the following description, information on the present invention is provided using expressions such as 'aaa table,' but this information may also be expressed using data structures other than a table. Hence, in order to express this idea that there is no dependence on data structure, 'aaa table,' 'aaa list,' 'aaaDB,' and 'aaa queue' and so on will sometimes also be referred to as 'aaa information.' Furthermore, although expressions such as 'identification information,' identifier, 'first name,' 'name,' and 'ID' are used when describing the content of each information item, such expressions are interchangeable.

(1) First Embodiment

(1-1) Configuration of Computer System

First, the configuration of a computer system **1** according to this embodiment will be described by referring to FIG. **1**. As shown in FIG. **1**, the computer system **1** according to this embodiment comprises a storage system **1050**, host computers **2000***a*, **2000***b* (hereinafter the host computers **2000***a*, **2000***b* will sometimes be referred to simply as the 'host computers **2000**'), data networks **3000***a*, **3000***b* (hereinafter the data networks **3000***a*, **3000***b* will sometimes be referred to simply as the 'data networks **3000**'), a management network **4000**, a management computer **5000**, and an I/O apparatus **6000**.

The storage system **1050** is configured from a plurality of storage apparatuses, namely, for example, a storage apparatus **1000***a* and a storage apparatus **1000***b*. The storage apparatus **1000***a* and storage apparatus **1000***b* may also be referred to in the following description simply as the 'storage apparatuses **1000**'. Furthermore, in order to clearly distinguish a storage apparatus connected to a certain storage apparatus from a connection-destination storage apparatus, the former may be referred to as the 'external connection-source storage apparatus, while the latter may be referred to as the 'external connection-destination storage apparatus.'

The plurality of storage apparatuses **1000** and host computers **2000** are connected via the data network **3000***a*. Furthermore, the plurality of storage apparatuses **1000** which the storage system **1050** comprises are interconnected via the data network **3000***b*. The data networks **3000***a* and **3000***b* may be SAN (Storage Area Networks), IP (Internet Protocol) networks, or may be data communication networks of a different kind.

Furthermore, the host computers **2000** and storage apparatuses **1000** are connected to the management computer **5000** via the management network **4000**. The management network **4000** may take the form of an IP network, for example, but may also be a SAN or another data communication network. In addition, the data networks **3000***a*, **3000***b* and the management network **4000** may be different networks or the same network. Moreover, although the host computers **2000** and the management computer **5000** are illustrated in this embodiment as separate computers, the embodiment is not limited to separate computers, rather, the host computers **2000** and the management computer **5000** may instead be configured as a single computer. Furthermore, the I/O apparatus **6000** is connected via the management computer **5000** and the management network **4000**.

The storage apparatus **1000** is an information processing apparatus which comprises a storage device storing data, parses commands which are transmitted from the host computer **2000**, and executes reads/writes from and to the storage area of the storage apparatuses **1000**. The host computer **2000** is a computer apparatus which executes various arithmetic processing corresponding to user tasks and is configured from a personal computer, a workstation or a mainframe or the like, for example.

The management computer **5000** is an information processing apparatus which the system administrator uses to manage the computer system **1** and is configured from a personal computer, a workstation, or a mainframe, or the like, for example. The I/O apparatus **6000** is a terminal device which accepts inputs from the system administrator and receives and outputs processing results and so forth transmitted from the management computer **5000** and is configured from input devices such as a keyboard, a switch, and a pointing device and output devices such as a display and a speaker, for example. In this embodiment, the management computer **5000** and the I/O apparatus **6000** are separate devices but the embodiment is not limited to this arrangement but the management computer **5000** and the I/O apparatus **6000** may also be configured as a single device.

Furthermore, in FIG. **1**, the computer system **1** is configured from one storage system which is configured from two storage apparatuses **1000**, two host computers **2000**, and one management computer **5000**, but the quantities of each of these devices are not restricted to these quantities.

An overview of this embodiment will be described here. Normally, if the amount of data handled by the computer system **1** increases, the increased data amount is handled by adding a new storage apparatus **1000** and migrating data between the existing storage systems **1050**.

The data units migrated between the storage systems **1050** are storage-area units which are used by the host computers **2000** to store data in the storage apparatus **1000** and exemplified by logical volumes which are configured from a single hard disk drive (HDD), by logical volumes in a RAID group which is configured from a plurality of hard disk drives, or by virtual volumes which use Thin Provisioning, for example.

Here, Thin Provisioning is a function which provides virtual volumes to the host computers **2000** and which, when there is a request from a host computer **2000** to write data to a virtual volume, dynamically assigns a physical storage area for storing data to the virtual volume. A Thin Provisioning function of this kind makes it possible to provide the host computer **2000** with a virtual volume of a larger capacity than the storage area that is actually provided. In addition, most recently, storage management has been performed efficiently by using hard disk drives of a plurality of types of varying performance. For example, in a management procedure known as ‘hierarchical storage management,’ a storage area is assigned from a high-speed, high-performance storage tier to an area where data of a high access frequency is stored and a storage area is assigned from a low-speed, low-performance storage tier to an area where data of a low access frequency is stored.

Furthermore, a technology is disclosed which involves acquiring information on a migration-source storage area where migrated data is stored and information on a data migration-destination storage area, calculating the time required to migrate the data, and creating an optimal data migration plan. For example, priority can be given to migrating data of a high access frequency by prioritizing the migration of data which is stored in a high-performance storage tier over the migration of data stored in a low-performance storage tier.

However, with the foregoing technology, in order to calculate the time required for data migration, the management computer **5000** which manages a plurality of storage apparatuses **1000** must acquire all the information relating to an optional storage area from the storage apparatus **1000***a* which is the data migration source and the storage apparatus **1000***b* which is the data migration destination. For this reason, there is a problem in that the amount of data which is transferred between the management computer **5000** and the storage apparatuses **1000** is huge and the overall performance of the storage system will likely be degraded. In the storage system **1** according to this embodiment, the data migration processing and so on can be made efficient by drastically reducing information relating to the storage areas of the storage apparatuses **1000** and by obtaining the same results as in a case where all the information relating to the storage areas is obtained.

(1-2) Configuration of each Device

(1-2-1) Storage Apparatus Configuration

The hardware configuration and the software configuration of the storage apparatuses **1000** will be described next. As shown in FIG. **2**, the storage apparatuses **1000** are configured from a disk controller **1200** which controls the whole storage apparatuses **1000** and the disk device **1100** which stores data.

The disk controller **1200** comprises a main memory **1210**, a control device **1220**, a host I/F **1230**, a management I/F **1240**, a disk I/F **1250**, and an external connection I/F **1260**. Note that a storage apparatus **1000** need not comprise an external connection I/F if this storage apparatus **1000** is used as an external connection destination.

The main memory **1210** stores a configuration management program **1211**, a statistical information creation program **1215**, a storage physical and logical storage area mapping table **1212**, a resource configuration table **1213**, and a storage external storage configuration table **1214**. Note that if the storage apparatuses **1000** are used as an external connection destination, the storage external storage configuration table **1214** need not be stored in the main memory **1210**. Furthermore, if the storage apparatuses **1000** are not compatible with the Thin Provisioning function, the storage physical and logical storage area mapping table **1212** need not be stored in the main memory **1210**. Details on each of the tables will be described subsequently.

The configuration management program **1211** is a program which manages configuration information and performance information on the storage apparatuses **1000**. The configuration management program **1211** refers to and updates the information which is stored in the storage physical and logical storage area mapping table **1212**, the resource configuration table **1213** or the storage external storage configuration table **1214**, for example. In addition, the configuration management program **1211** transmits and receives various information by communicating with a system management program **5110** of the management computer **5000** (described subsequently).

The statistical information creation program **1215** comprises a function for creating statistical information relating to the configuration of the storage apparatuses **1000** in response to a request from the management computer **5000**. Here, statistical information is information which corresponds to units of a predetermined storage area and the granularity of predetermined statistical information, the storage-area units being exemplified by logical volumes or virtual volumes and the granularity of predetermined statistical information being exemplified by the number of segments assigned for each resource and the data occupancy in the logical volumes and the like. The statistical information creation program **1215** acquires information which corresponds to the units of the storage areas and the granularity of the statistical information which are provided by the management computer **5000** from each of the tables. Each of the tables stored in the main memory **1210** will be subsequently described in detail.

The control device **1220** functions as an arithmetic processing device and controls the overall operation of the storage apparatuses **1000** according to various programs and computation parameters and so on which are stored in the main memory **1210**.

The host I/F **1230** is an interface for connecting to the host computers **2000** via the data network **3000** and transmits and receives various information such as data and control commands to and from the host computers **2000**. The management I/F **1240** is an interface for connecting to the host computers **2000** and the management computer **5000** via the management network **4000**, and sends and receives the various information such as data and control commands to the host computers **2000** and the management computer **5000**.

The disk I/F **1250** is an interface which connects the disk controller **1200** and the disk device **1100** and which sends and receives the various information such as data and control commands to and from the disk device **1100**. The external connection I/F **1260** is an interface for connecting the data network **3000** and the externally connected storage apparatuses **1000** and sends and receives the various information such as data and control commands to and from the externally connected storage apparatus **1000**.

The disk device **1100** is configured from a plurality of physical devices (PDEV) **1150***a*, **1150***b*, **1150***c*, and **1150***d* (which hereinafter may be described as 'physical devices (PDEV) **1150**'). The logical configuration of the disk device **1100** will be described here.

As shown in FIG. **3**, the disk device **1100** comprises one or more logical volumes **1110** (**1110***a*, **1110***b*, **1110***c*, **1110***d*) and a pool **1120**. The logical volumes **1110** are logical storage areas which serve as data storage units and are generated from one or more physical resources **1121** or virtual resources **1122**. The logical volumes **1110** store various data which is read/written by the host computers **2000**. Note that, in this embodiment, the disk device **1100** is provided with four logical volumes **1110** and a single pool **1120** but the number of logical volumes and so on is not limited to this quantity.

The pool **1120** is configured from one or more physical resources **1121** or one or more virtual resources. The pool **1120** may be a set of storage areas which the storage apparatuses **1000** provide to the host computers **2000** and may, for example, be a pool which is provided by a RAID group or a pool that is provided by Thin Provisioning. For example, in the case of a pool provided by a RAID group, a single RAID group is configured from a plurality of disks and one or more logical volumes are defined in a storage area provided by the single RAID group. Furthermore, logical volumes which are provided by a plurality of RAID groups are managed as a single pool. RAID groups are exemplified by 'RAID0', which integrates a plurality of hard disk devices as one device and provides the device as an enormous storage area and by 'RAID1', which performs mirroring between hard disks in order to increase the redundancy of the hard disk devices, for example.

In FIG. **3**, the pool **1120** is configured from a physical resource **1121** and a virtual resource **1122** but is not limited to these resources, rather, the pool **1120** may also be configured from the physical resource **1121** alone or may be configured from only the virtual resource **1122**. In addition, in this embodiment, a logical device which is in a RAID configured from a plurality of physical devices (PDEV) **1150** is defined as a physical resource. Furthermore, a logical device which is created in the external connection-source storage system **1050** is defined, according to external connection technology, as a virtual resource. Moreover, absent the need to make a particular distinction between physical resources and virtual resources, these resources may be described simply as 'resources.'

Furthermore, various types of the logical volume **1110** are shown in FIG. **3**. These types of logical volume **1110** are, for example, a normal logical volume **1110***a*, an externally connected volume **1110***b*, a Thin Provisioning volume **1110***c*, and a dynamic Thin Provisioning **1110***d* or the like.

The normal logical volume **1110***a* is a logical storage area which is configured from a physical resource **1121** (a RAID group or the like) which is constructed from hard disk devices. Further, the actual storage area of the externally connected volume **1110***b* exists in an external connection destination (the storage apparatus **1000***b*, for example) and is a logical storage area which is configured from a virtual resource **1122**.

Furthermore, the Thin Provisioning volume **1110***c* is a logical volume which has a dynamically expanded capacity as mentioned earlier. The Thin Provisioning volume **1110***c* can have its volume capacity dynamically expanded by assigning a segment (predetermined area) from the physical resource **1123** or virtual resource **1124** which is contained in the pool **1120** at the point where a data write request from the host computer **2000** is received.

In addition, the dynamic Thin Provisioning volume **1110***d* is a logical volume which can have its capacity expanded dynamically in the same way as the Thin Provisioning volume **1110***c*. With the dynamic Thin Provisioning volume **1110***d*, once assigned, segments can be dynamically assigned to segments of a different performance (responsiveness, reliability and the like) depending on the logical volume access status.

Note that, in FIG. **3**, the Thin Provisioning volume **1110***d* and the dynamic Thin Provisioning volume **1110***c* have segments assigned from both the physical resource **1123** and the virtual resource **1124** but the arrangement is not limited to this example, rather, segments may also be assigned from either one of the physical resource **1123** and the virtual resource **1124**.

Details of each of the tables stored in the main memory **1210** will be provided next with reference to FIGS. **4** to **7**.

The storage physical and logical storage area mapping table **1212** is a table which manages correspondence relationships between logical addresses of the logical volumes **1110** and the addresses of the physical resources **1121** or virtual resources **1122** in the Thin Provisioning function. The storage physical and logical storage area mapping table **1212** is, as shown in FIG. **4**, configured from a volume identifier field **12120**, a logical start address field **12121**, a logical end address field **12122**, a pool identifier field **12123**, a resource identifier field **12124**, a physical start address field **12125**, and a physical end address field **12126**.

The volume identifier field **12120** stores a volume identifier which identifies each of the logical volumes **1110**. Furthermore, the logical start address field **12121** stores the start addresses of the segments of the logical volumes **1110** and the logical end address field **12122** stores the end addresses of the logical volumes **1110** which correspond to the logical start addresses stored in the logical start address field **12121**.

Furthermore, the pool identifier field **12123** stores pool identifiers identifying pools which have a resource which is a segment assignment source. The resource identifier field **12124** stores resource identifiers which are identifiers of the physical resources **1121** or virtual resources **1122** of the pool **1120**. The physical start address field **12125** stores the resource start addresses of the physical resources **1120** or the virtual resources **1122** of the pool **1120**, and the physical end address field **12126** stores the resource end addresses of the physical resources **1120** or the virtual resources **1122** of the pool **1120**.

Here, the information stored in the storage physical and logical storage area mapping table **1212** will be described.

FIG. **5** shows an example of information which is stored in the storage physical and logical storage area mapping table **1212** shown in FIG. **4**. As shown in FIG. **5**, numbers **1000** to **1999** of the physical resource in the pool **1120** with the pool identifier '**1**' correspond to numbers **0** to **999** of the logical volume **1110** (volume identifier is '**0**'). Likewise, numbers **0** to **999** of physical resource '**1**' correspond to the numbers **1000** to **1999** of the logical volume (volume identifier is '**0**') **1110**. Furthermore, numbers **0** to **2999** of physical resource '**2**' correspond to the numbers **2000** to **3999** of the logical volume (volume identifier is '**0**') **1110**. In addition, numbers **4000** to **199999** of the logical volume **1110** are in a state of having no physical resource assigned thereto. Note that the correspondence relationship shown in FIG. **5** is dynamically changed by the dynamic Thin Provisioning volume **1110***d*.

The resource configuration table **1213** will be described next. The resource configuration table **1213** is a table which manages information relating to resources which are provided in the disk devices **1110** of the storage apparatuses **1000**. As shown in FIG. **6**, the resource configuration table **1213** is configured from a pool identifier field **12130**, a resource identifier field **12131**, a resource type field **12132**, and a resource configuration field **12133**.

The pool identifier field **12130** stores pool identifiers identifying pools to which each resource belongs. The resource identifier field **12131** stores resource identifiers identifying each of the resources. The resource type field **12132** stores information indicating the type of each resource. The resource type denotes the type of storage medium, examples of which are FC (Fibre Channel), SSD (Solid State Drive) and SATA (Serial AT Attachment), and the like. The resource configuration field **12133** stores information indicating the configuration of resources. Information indicating the resource configuration is information indicating physical resources in the storage apparatuses **1000** or virtual resources of an external storage apparatus connected to the storage apparatuses **1000**. In FIG. **6**, physical resources in the storage apparatuses **1000** are 'internal' and virtual resources outside the storage apparatus are 'external.'

The storage external storage configuration table **1214** will be described next. The storage external storage configuration table **1214** is a table for managing the correspondence relationship between the virtual resource **1122** in the storage apparatus **1000***a* (hereinafter described as the 'externally connected source storage apparatus **1000***a*') which is an externally connected connection source, and the logical volume of the storage apparatus **1000***b* (hereinafter called the 'external connection destination storage apparatus **1000***b*') which is an externally connected connection destination. As shown in FIG. **7**, the storage external storage configuration table **1214** is configured from a resource identifier field **12140**, a port identifier field **12141**, an external storage identifier field **12142**, an external storage resource identifier field **12143** and an external storage port identifier field **12144**.

The resource identifier field **12140** stores resource identifiers identifying the virtual resources **1122** of the external connection source storage apparatus **1000***a*. The port identifier field **12141** stores port identifiers which identify ports, of the external connection source storage apparatus **1000***a*, which connect virtual resources **1122** of the external connection source storage apparatus **1000** and the logical volumes **1110** of the external connection destination storage apparatus **1000***b*.

The external storage identifier field **12142** stores identifiers which identify the external connection destination storage apparatus **1000***b* which corresponds to the virtual resources **1122** of the external connection source storage apparatus **1000***a*. The identifiers may be information in any format as long as these identifiers are information which makes it possible to specify the external connection destination storage apparatus **1000***b*.

The external storage resource identifier field **12143** stores identifiers which identify resources constituting the logical volumes **1110** of the external connection destination storage apparatus **1000***b* which correspond to the virtual resources **1122** of the external connection source storage apparatus **1000***a*. In addition, the external storage port identifier field **12144** stores port identifiers which identify ports, of the external connection source storage apparatus **1000***a*, which connect the virtual resources **1122** of the external connection source storage apparatus **1000***a* and the logical volume **1110** of the external connection destination storage apparatus **1000***b*.

(1-2-2) Configuration of Host Computer

The hardware configuration and software configuration of the host computer **2000** will be described next with reference to FIG. **8**. As shown in FIG. **8**, the host computer **2000** comprises a main memory **2100**, a control device **2200**, a host I/F **2300**, and a management I/F **2400**. Note that the host computer **2000** may also be provided with I/O devices, not shown, such as a keyboard and display device and the like.

The main memory **2100** stores various programs and computation parameters and so on. The control device **2200** functions as an arithmetic processing device and controls the whole operation of the host computer **2000** according to various programs and computation parameters and the like stored in the main memory **2100**.

The host I/F **2300** is an interface for connecting to the storage apparatuses **1000** via the data network **3000** and sends and receives various information such as data and control commands to the storage apparatus **1000**. The management I/F **2400** is an interface for connecting to the storage apparatus **1000** or management computer **5000** via the management network **4000** and sends and receives various information such as data and control commands to and from the storage apparatuses **1000** or the management computer **5000**.

(1-2-3) Management Computer Configuration

The hardware configuration and software configuration of the management computer **5000** will be described next with reference to FIG. **9**. As shown in FIG. **9**, the management computer **5000** comprises a main memory **5100**, a control device **5200**, a management I/F **5300**, and a host I/F **5400**.

The main memory **5100** stores the system management program **5110**, a data migration required time computation program **5112**, a statistical information acquisition program **5113**, a resource management table **5150**, a management external storage configuration table **5155**, a management physical and logical storage area mapping table **5160**, a disk type performance information table **5170**, and a port performance information table **5180**.

The system management program **5110** is a program which manages the configuration of the storage system **1050** and which, more specifically, acquires the configuration information of the storage apparatuses **1000** from the configuration management program **1211** of the storage apparatuses **1000** and updates the resource management table **5150** and the management external storage configuration table **5155** based on the acquired information.

The data migration required time computation program **5112** is a program for accepting inputs of information on the migration target volume and migration destination volume in response to a user operation, and refers to the resource management table **5150**, the management external storage configuration table **5155**, the management physical and logical storage area mapping table **5160**, the disk type performance information table **5170** and the port performance information table **5180** and calculates the input time required for data migration between the volumes.

The statistical information acquisition program **5113** accepts, in response to a user operation and as targets for acquiring statistical information, inputs of optional storage area units and of statistical information granularity and provides information which is input to the statistical information creation program **1215** of the storage apparatuses **1000**. The statistical information acquisition program **5113** acquires statistical information which corresponds to the input from the statistical information creation program **1215** of the storage apparatuses **1000**.

The resource management table **5150** will be described next. The resource management table **5150** is a table which manages information on the resources of one or more storage apparatuses **1000** which are managed by the management computer **5000**. As shown in FIG. **10**, the resource management table **5150** is configured from an apparatus identifier field **51500**, a pool identifier field **51501**, a resource identifier field **51502**, a resource type field **51503**, and a resource configuration field **51504**.

The apparatus identifier field **51500** stores storage-apparatus identifiers which identify the storage apparatuses **1000**. The pool identifier field **51501** stores pool identifiers identifying the pools **1120** of the storage apparatus **1000**. The resource identifier field **51502** stores resource identifiers which identify the resources in each of the pools. The resource type field **51503** stores information indicating the types of each resource. Resource type denotes the type of storage media, examples of which include FC, SSD, and SATA and so on. The resource configuration field **51504** stores information indicating the resource configuration. Information indicating the resource configuration is information which indicates the physical resource in the storage apparatus **1000** or the virtual resource of an external storage apparatus connected to the storage apparatus **1000**. In FIG. **10**, the physical resources in the storage apparatuses **1000** are denoted ‘internal’ and the virtual resources outside the storage apparatuses are denoted ‘external.’

The management external storage configuration table **5155** will be described next. The management external storage configuration table **5155** is a table which is managed by the management computer **5000** and shows the external connection configuration between one or more storage apparatuses **1000***a* and the externally connected external storage apparatus **1000***b*. The management external storage configuration table **5155** is, as shown in FIG. **11**, configured from a storage identifier field **51550**, a resource identifier field **51551**, a port identifier field **51552**, an external storage identifier field **51553**, an external storage resource identifier **51554**, and an external storage port identifier field **51555**.

The storage identifier field **51550** stores storage identifiers identifying the external connection source storage apparatus **1000***a*. The resource identifier field **51551** stores resource identifiers identifying virtual resources **1122** in the external connection source storage apparatus **1000***a*. The port identifier field **51552** stores port identifiers identifying ports, of the external connection source storage apparatus **1000***a*, which connect the virtual resources **1122** in the external connection source storage apparatus **1000***a* to the logical volumes **1110** in the external connection destination storage apparatus **1000***b*.

The external storage identifier field **51553** stores external storage identifiers which identify the external connection destination storage apparatus **1000***b* corresponding to the virtual resources **1122** in the external connection source storage apparatus **1000***a*. The external storage resource identifier **51554** stores external storage resource identifiers which identify resources constituting the logical volumes in the external connection destination storage apparatus **1000***b* corresponding to the virtual resources **1122** in the external connection source storage apparatus **1000***a*. The external storage port identifier field **51555** stores external storage port identifiers which identify ports, of the external connection source storage apparatus **1000***b*, which connect the virtual resources **1122** in the external connection source storage apparatus **1000***a* to the logical volumes **1110** in the external connection destination storage apparatus **1000***b*.

The management physical and logical storage area mapping table **5160** will be described next. The management physical and logical storage area mapping table **5160** is a table which manages optional statistical information relating to the configuration of the storage apparatus **1000**. More specifically, the statistical information acquisition program **5113** acquires, from the storage apparatus **1000**, optional statistical information based on the information in the storage physical and logical storage area mapping table **1212** of the storage apparatuses **1000** and stores this information in the management physical and logical storage area mapping table **5160**. The statistical information is, for example, information corresponding to predetermined storage area units and the granularity of predetermined statistical information, where examples of storage area units include logical volumes and virtual volumes and examples of statistical information granularity include the number of segments of each resource which are assigned and data occupancy in the logical volumes. In FIG. **12**, an example is illustrated in which numbers of segments of resources assigned to the virtual volume are stored as statistical information.

The management physical and logical storage area mapping table **5160** is, as shown in FIG. **12**, configured from an apparatus identifier field **51600**, a volume identifier field **51601**, a pool identifier field **51602**, a resource identifier field **51603**, and an assigned segment count **51604**. The apparatus identifier field **51600** stores apparatus identifiers identifying storage apparatuses **1000**. The volume identifier field **51601** stores volume identifiers identifying the logical volumes **1110**. The pool identifier field **51602** stores pool identifiers identifying pools with resources which are segment assignment sources. The resource identifier field **51603** stores resource identifiers which are identifiers of the physical resources **1121** or virtual resources **1122** of the pool **1120**.

The assigned segment count **51604** stores the number of segments of the optional resources assigned to each volume. For example, among the information stored in the storage physical and logical storage area mapping table **1212**, a value obtained by totaling the numbers of segments assigned from resources of the same type is stored.

The disk type performance information table **5170** will be described next. The disk type performance information table **5170** is a table which manages the read/write performance of each resource of the physical resources **1121** or the virtual resources **1122**. The disk type performance information table **5170** is, as shown in FIG. **13**, configured from an apparatus identifier field **51700**, a resource identifier field **51701**, a read performance field **51702** and a write performance field **51703**.

The apparatus identifier field **51700** stores apparatus identifiers identifying the storage apparatuses **1000**. The resource type field **51701** stores information indicating the types of each resource. The resource type denotes the types of storage media, examples of which are FC, SSD, and SATA, and the like. The read performance field **51702** stores the read performance corresponding to the resource types. The read performance is indicated in 'G/sec' units, for example, but the embodiment is not limited to this example and may be expressed using different units. The write performance field **51703** stores the write performance corresponding to the resource type. For example, the write performance is indicated using 'G/sec' but the embodiment is not limited to this example and may be expressed using different units.

The port performance information table **5180** will be described next. The port performance information table **5180** is a table for managing IOPS (Input Output Per Second), which indicates the performance of each port contained in the storage apparatus **1000**. The port performance information table **5180** is, as shown in FIG. **14**, configured from an apparatus identifier field **51800**, the port identifier field **51801** and the maximum IOPS field **51802**.

The apparatus identifier field **51800** stores apparatus identifiers identifying the storage apparatuses **1000**. The port identifier field **51801** stores port identifiers identifying each of the ports contained in the storage apparatuses **1000**. The maximum IOPS field **51802** stores the IOPS values of each of the ports. IOPS values of ports contained in catalogues and manuals and the like may be stored as the IOPS values. Furthermore, measurement values of the IOPS of the ports acquired from the storage apparatuses **1000** may be stored by the system management program **5110** and or predicted values obtained by assigning a trend derived from a plurality of previously measured measurement values may be stored by the system management program **5110**.

Returning to FIG. **9**, a control device **5200** functions as a arithmetic processing device and controls the operation of the whole management computer **5000** according to the various programs and computation parameters which are stored in the main memory **5100**.

The management I/F **5300** is an interface for connecting to the storage apparatuses **1000** and the host computers **2000** via the management network **4000** and for sending and receiving various information such as data and control commands to the storage apparatuses **1000** and host computers **2000**.

The host I/F **5400** is an interface for connecting to the host computers **2000** via the management network **4000** and sends and receives various information such as data and control commands to the host computers **2000**.

Note that each of the functions provided in the foregoing storage apparatuses **1000**, the host computers **2000** and the management computer **5000** are implemented by each of the programs which are read from the main memory of each of the apparatuses and executed by the control devices of each apparatus. The programs may each be pre-stored in the main memory of each of the apparatuses and may, if necessary, be stored in the main memory from other devices via media which are available to each of the apparatuses. The media available to each of the apparatuses may, for example, be storage media which is detachably mounted in a reading apparatus or the like, a network connected to each apparatus, or a communication medium such as a carrier wave or digital signal or the like which is propagated over the network.

(1-3) Details of the Operation of each Apparatus

Details of the operation of each apparatus in the computer system **1** will be provided next. In particular, the operation of the management computer **5000** which executes the processing pertaining to the embodiment will be described in detail below.

Although the subject of the following description is sometimes 'programs,' the processing which is determined as a result of the programs being executed by the control device is performed while using the main memory and ports (communication control devices) and hence the subject of the description may also be the control device. Furthermore, the processing which is disclosed by taking the program as the subject may also be processing which is performed by a computer or information processing device such as a management computer. In addition, one or all of the programs may also be implemented by dedicated hardware. Furthermore, various programs may be installed on each computer by storage media (computer-readable memory media) which can be read by a program distribution server or a computer.

First, the processing of the system management program **5110** will be described in detail. The system management program **5110** may execute the following processing at regular intervals or may execute this processing in response to a user operation. The system management program **5110** performs processing to acquire configuration information from the storage apparatuses **1000** and store the configuration information thus acquired in a predetermined table.

More specifically, as shown in FIG. **15**, the system management program **5110** requests configuration information on resources in the storage apparatuses **1000** and external storage from the configuration management program **1211** of the storage apparatuses **1000** (**S1010**).

Furthermore, the system management program **5110** acquires information in the resource configuration table **1213** and the storage external storage configuration table **1214** in the storage apparatuses **1000** acquired by the configuration management program **1211** (**S1020**).

Further, the system management program **5110** stores the configuration information acquired in step **S1020** in the resource management table **5150** and the management external storage configuration table **5155** (**S1030**). More specifically, the system management program **5110** associates the apparatus identifiers and resource configuration information of each storage apparatus **1000** and stores the identifiers and information in the resource management table **5150**. Furthermore, the system management program **5110** associates the apparatus identifiers (storage identifiers) of each storage apparatus **1000** with the external storage configuration information thereof and stores the identifiers and information in the management external storage configuration table **5155**.

The processing of the data migration required time computation program **5112** will be described in detail next. The data migration required time computation program **5112** may execute the following processing in response to an input from the system administrator or may execute the following processing in response to a request from a monitoring program (not shown) for monitoring the state of assignment of resources to logical volumes of the storage apparatuses **1000**.

As shown in FIG. **16**, the data migration required time computation program **5112** performs processing to calculate the time required for data migration in response to an input from the system administrator. More specifically, the data migration required time computation program **5112** first acquires information for data migration which is input by the system administrator via the I/O apparatus **6000** (S**2005**). The information for data migration is information on the volumes (logical volumes) serving as data migration targets and information on data migration-destination volumes, for example. The volume information is information identifying the resources indicated in FIG. **10** or FIG. **11**, and so on, for example.

Further, the data migration required time computation program **5112** issues a request for statistical information corresponding to a predetermined input to the statistical information acquisition program **5113** (S**2010**). More specifically, the data migration required time computation program **5112** provides information on the migration-source volume and information on the migration-destination volume acquired in step S**2005**, the statistical information units, and the granularity and type of the statistical information to the statistical information acquisition program **5113** and acquires statistical information which corresponds to inputs from the statistical information acquisition program **5113**. Here, the statistical information units can, for example, be virtual volume units, and the statistical information granularity and type can, for example, be the number of assigned segments of each resource.

Furthermore, the data migration required time computation program **5112** acquires statistical information relating to resource assignment of designated volumes acquired in step (S**2010**). Note that, in this embodiment, the acquired statistical information is information relating to the assignment of volume resources but is not limited to this example, rather, this is information which changes according to the inputs in step S**2010**. The processing to acquire the statistical information by the statistical information acquisition program **5113** will be described in detail subsequently.

The data migration required time computation program **5112** then stores the statistical information acquired in step S**2020** in the management physical and logical storage area mapping table **5160** (S**2030**). As mentioned earlier, the management physical and logical storage area mapping table **5160** stores, among the information stored in the storage physical and logical storage area mapping table **1212**, a value obtained by totaling the numbers of segments assigned from resources of the same type. It is thus possible to collectively acquire less information than all the information stored in the storage physical and logical storage area mapping table **1212** and therefore the amount of data transferred and the transfer time can be greatly reduced.

Furthermore, the data migration required time computation program **5112** calculates the time required for data migration based on information which is stored in the resource management table **5150**, the management external storage configuration table **5155**, the management physical and logical storage area mapping table **5160**, the disk type performance information table **5170**, and the port performance information table **5180** (S**2040**).

Here, a specific example of data migration required time calculation processing will be described. As shown in FIG. **17**, the data migration required time computation program **5112** refers to the management physical and logical storage area mapping table **5160** and specifies resources constituting the volume which is the data migration target that was input in step S**2005** (S**2050**).

The data migration required time computation program **5112** then refers to the resource management table **5150** and specifies the type and configuration of the resources specified in step S**2050** (S**2052**).

Furthermore, the data migration required time computation program **5112** determines whether or not the configuration information specified in step S**2052** is external (S**2054**). If it is determined in step S**2054** that the configuration information is external, the data migration required time computation program **5112** refers to the management external storage configuration table **5155** and specifies the port which is used for the external connection and corresponding to the specified resource (S**2056**). In addition, the data migration required time computation program **5112** refers to the port performance information table **5180** and specifies the performance information of the port specified in step S**2056** (S**2058**).

If it is determined in step S**2054** that the configuration information is not external, the data migration required time computation program **5112** executes the processing of step S**2060**. The data migration required time computation program **5112** then refers to the disk type performance information table **5170** and specifies the read/write performance corresponding to the type of resource specified in step S**2050** (S**2060**).

The data migration required time computation program **5112** then calculates the data migration required time of the data stored in the resources specified in step S**2050** (S**2062**). For example, if the migration source volume is a 200 GB SSD and a 800 GB FC, the SSD read performance is specified as 10 (G/sec) and the FC read performance is specified as 8 (G/sec) in step S**2060**. The time required for data migration of the migration-source volume is therefore calculated by the following equation.

[Math 1]

$$200/10+800/8=120\ (\text{sec}) \tag{1}$$

If the migration-destination volume is configured by a virtual resource in a 1000GB FC, the port performance is specified in step S**2058**. If the port performance maximum IOPS is 10 (G/sec), the port performance may also be 10/5 (G/sec). In addition, the FC write performance is specified as being 4 (G/sec) in step S**2060**. Hence, the time required for data migration to the migration-destination volume is therefore 1000/4+1000/5=250+200=450 (sec). The data migration required time computation program **5112** accordingly makes the data migration required time equal to a value (120+450=570 (sec)) which is obtained by adding the data migration required time of the migration-source volume to the data migration required time of the migration-destination volume.

The data migration required time computation program **5112** then determines whether or not to calculate the data migration required time for all the resources (S**2064**) and, if it is determined in step S**2064** that the data migration required time has been calculated for all the resources, the data migration required time computation program **5112** terminates the processing. If, however, it is determined in step S**2064** that that the data migration required time has not been calculated for all the resources, the data migration required time computation program **5112** repeats the processing of step S**2050** and subsequent steps.

Details of the processing of the statistical information acquisition program **5113** will be described next. The statistical information acquisition program **5113** issues a request for predetermined statistical information to the statistical information creation program **1215** of the storage apparatuses **1000**. The statistical information acquisition program **5113** executes the following statistical information acquisition processing based on the aforementioned instruction from the data migration required time computation program **5112**.

As shown in FIG. **18**, the statistical information acquisition program **5113** first accepts an input of information on the statistical information acquisition target from the data migration required time computation program **5112** (S**3005**). The statistical information acquisition target information is, for example, the units of the statistical information acquisition target, information specifying the statistical information acquisition target, and the granularity or type of statistical information. More specifically, an example of a statistical information acquisition target unit is a virtual volume, an example of the information specifying the statistical information acquisition target is a migration-source or migration-destination logical volume, and an example of information on the granularity or type of statistical information is the segment assignment count for each resource.

Furthermore, the statistical information acquisition program **5113** provides the information on the statistical information acquisition target which was accepted in step S**3005** to the statistical information creation program **1215** of the storage apparatus **1000** and issues a request for statistical information to the statistical information creation program **1215** (S**3010**).

Furthermore, the statistical information acquisition program **5113** acquires statistical information corresponding to the information on the statistical information acquisition target from the statistical information creation program **1215** (S**3020**). More specifically, the statistical information creation program **1215** creates, as statistical information, a value obtained by adding the number of segments assigned to the virtual volume to each of the resources, for the targeted virtual volume among the migration-source or migration-destination logical volumes, for example, and provides this value to the statistical information acquisition program **5113**.

Note that, in step S**3010**, the statistical information acquisition program **5113** may also transmit the acquired time to the statistical information creation program. In this case, the statistical information acquisition program **5113** may also acquire statistical information only at points where the configuration has changed since the previous time of acquisition within the range of the statistical information acquired from the statistical information creation program in step S**3020**. Using this method, the amount of data transferred between the management computer **5000** and the storage apparatuses **1000** can be further reduced.

(2) Second Embodiment

The second embodiment of the present invention will be described next with reference to FIGS. **19** to **22**. According to the first embodiment, an example of the statistical information which is transferred from the storage apparatuses **1000** to the management computer **5000** is data relating to the segment assignment information constituting the virtual volume; however, according to the second embodiment, in addition to the segment assignment information, the segment IOPS information and the information on assigning the segments of the resources in the pool differ from those of the first embodiment in that the segment IOPS information is transferred. A configuration which differs from that of the first embodiment is described in detail hereinbelow, and a detailed description of the same configuration as that of the first embodiment is not included.

As shown in FIG. **19**, the management computer **5000** according to this embodiment is configured from the main memory **5100**, the control device **2200**, the management I/F **5300**, and the host I/F **5400**.

The control device **2200**, the management I/F **5300**, and the host I/F **5400** have the same functions as those of the first embodiment and a detailed description thereof is not included.

The main memory **5100** stores the system management program **5110**, a migration-destination volume performance prediction program **5114**, the statistical information acquisition program **5113**, the resource management table **5150**, the management external storage configuration table **5155**, a management physical and logical storage area mapping table **5160**B, the disk type performance information table **5170**, the port performance information table **5180**, and a management pool physical and logical storage area mapping table **5190**. In this embodiment, the data migration required time computation program **5112** described in the first embodiment is not stored in the main memory **5100** but the data migration required time computation program **5112** may also be stored in the main memory **5100**.

Programs and tables which differ from those of the first embodiment will be described hereinbelow in particular detail. The migration-destination volume performance prediction program **5114** is a program which predicts the performance (response time, for example) in a case where data of an optional dynamic Thin Provisioning volume (hereinafter called the 'dynamic virtual volume') is migrated to a dynamic virtual volume which belongs to a different pool. Note that, although the volume serving as the performance prediction target of the migration-destination volume performance prediction program **5114** is a dynamic virtual volume in this embodiment, the embodiment is not limited to this example, rather, the logical volume **1110** described in the first embodiment may also be a normal logical volume **1110***a* or external connection volume **1110***b*, for example. In addition, according to this embodiment, the rule for migrating the data of the dynamic virtual volume is a rule according to which the higher the IOPS of the data, the higher the performance of the resources whose segments the data is migrated to, but the embodiment is not limited to this example. Here, an example of performance is a value (G/sec) indicated in a manual or catalogue or the like.

The management physical and logical storage area mapping table **5160**B will be described next. As shown in FIG. **20**, the management physical and logical storage area mapping table **5160**B is a table for managing optional statistical information relating to the configuration of the storage apparatuses **1000**. The management physical and logical storage area mapping table **5160**B holds information on the average IOPS to the optional assigned segment in addition to the information stored in the management physical and logical storage area mapping table **5160** according to the first embodiment.

More specifically, the average IOPS field **51605** stores average values of the IOPS values of the segments of the optional resource assigned to the volumes. Note that, according to this embodiment, although the IOPS values held in the management physical and logical storage area mapping table **5160**B are values for the average IOPS of the assigned segments, statistical information indicating an IO distribution of the 50 percentile, for example, may also be stored.

The management pool physical and logical storage area mapping table **5190** will be described next. The management pool physical and logical storage area mapping table **5190** is a table which manages statistical information relating to the resources in the pool **1120** of the storage apparatuses **1000** and, as shown in FIG. **21**, the management pool physical and logical storage area mapping table **5190** is configured from an apparatus identifier field **51900**, a pool identifier field **51901**, a resource identifier field **51902**, a total segment count field **51903**, an assigned segment count field **51904**, and an average IOPS to the assigned segment field **51905**.

The apparatus identifiers field **51900** stores apparatus identifiers which identify the storage apparatuses. The pool identifier field **51901** stores pool identifiers which identify pools. The resource identifier field **51902** stores resource identifier fields identifying resources. The total segment count field **51903** stores the total segment count of the resources. The assigned segment count field **51904** stores the numbers of assigned segments among the segments of the resources. The average IOPS to the assigned segment field stores values for the average IOPS to the assigned segments of optional resources.

The operation of the management computer **5000** according to this embodiment will be described in detail next. Hereinafter, processing pertaining to this embodiment which differs from the first embodiment in particular will be described. Details of the processing of the migration-destination volume performance prediction program **5114** in particular will be described hereinbelow.

As shown in FIG. **22**, the migration destination volume performance prediction program **5114** first acquires information for data migration that is input by the system administrator via the I/O apparatus **6000** (S**4010**). Information for data migration is, for example, information on the volume serving as a data migration target (logical volume) and information on the data migration-destination volume, and the like.

The migration-destination volume performance prediction program **5114** subsequently issues a request for statistical information corresponding to a predetermined input to the statistical information acquisition program **5113** (S**4020**). More specifically, the migration destination volume performance prediction program **5114** supplies, to the statistical information acquisition program **5113**, information on the migration-source volume and information on the migration-destination volume which were acquired in step S**4010**, and units, granularity and type of the statistical information to the statistical information acquisition program **5113**, and acquires statistical information which corresponds to an input from the statistical information acquisition program **5113**. Here, the units of the statistical information are virtual volumes and pools and the granularity and type of the statistical information are the segment assignment count and average IOPS for each resource. Note that, although the segment assignment count and average IOPS for each resource is exemplified by the granularity and type of the statistical information in this embodiment, the granularity and type may also be a 50-percentile granularity and type.

Furthermore, the migration-destination volume performance prediction program **5114** acquires statistical information relating to the resource assignment of designated volumes acquired in step S**2010** (S**4030**). Note that, although information relating to the resource assignment and average IOPS of the volume is the statistical information acquired in this embodiment, the embodiment is not limited to this example.

The migration-destination volume performance prediction program **5114** subsequently stores the statistical information acquired in step S**4030** in the management physical and logical storage area mapping table **5160**B and the management pool physical and logical storage area mapping table **5190** (S**4040**). As described hereinabove, the management physical and logical storage area mapping table **5160**B stores, among the information stored in the storage physical and logical storage area mapping table **1212**, the average IOPS of each resource and a value obtained by totaling the numbers of segments assigned from resources of the same type. Accordingly, since it is possible to collectively acquire a smaller amount of information than all the information stored in the storage physical and logical storage area mapping table **1212**, the amount of transferred data and the transfer time can be greatly shortened.

Furthermore, the migration-destination volume performance prediction program **5114** calculates the performance of the migration-destination dynamic virtual volume on the basis of information stored in the resource management table **5150**, the management external storage configuration table **5155**, the management physical and logical storage area mapping table **5160**B, the disk type performance information table **5170**, the port performance information table **5180**, and the management pool physical and the logical storage area mapping table **5190** (S**4050**).

A specific example of the migration-destination volume performance prediction processing is described here. As shown in FIG. **23**, the migration-destination volume performance prediction program **5114** refers to the management physical and logical storage area mapping table **5160** and specifies the resources constituting the pool corresponding to the migration-destination volume and resources constituting the migration-source volume which are input in step S**4010** (S**4060**).

The migration-destination volume performance prediction program **5114** refers to the resource management table **5150** and specifies the type and configuration of the resources specified in step S**4060** (S**4062**).

The migration-destination volume performance prediction program **5114** then determines whether or not the configuration information specified in step S**4062** is external (S**4064**). If it is determined in step S**4064** that the configuration information is external, the migration-destination volume performance prediction program **5114** refers to the management external storage configuration table **5155** and specifies the port, used for the external connection, which corresponds to the specified resource (S**4066**). Furthermore, the migration-destination volume performance prediction program **5114** refers to the port performance information table **5180** and specifies performance information for the port specified in step S**4066** (S**4068**).

If it is determined in step S**4064** that the configuration information is not external, the processing of step S**4070** is executed. The migration-destination volume performance prediction program **5114** then refers to the disk type performance information table **5170** and specifies the read/write performance corresponding to the type of resource specified in step S**4060** (S**4070**).

The migration-destination volume performance prediction program **5114** subsequently computes the performance of the migration-destination volume in the migration of the resource specified in step S**4060** (S**4072**). For example, suppose that the migration-source volume is configured from 1000 segments (average IOPS=5000) of a resource **1**, 1000 segments (average IOPS=6000) of a resource **2**, and 2000 segments (average IOPS=3000) of a resource **3**. Furthermore, suppose that it is possible to specify, for the pool corresponding to the migration-destination volume, that all the segments (1000 segments) of a resource **10** are assigned (average IOPS=4000), that all the segments (1000 segments) of a resource **11** are assigned (average IOPS=3000), and that 2000 segments among all 8000 segments of resource **2** are assigned (average IOPS=2500).

In addition, as described earlier, the rule for data migration of a dynamic virtual volume is that the higher the IOPS of the data, the higher the performance of the resource segment the data is migrated to, and hence it can be inferred that high-performance resources are assigned in the following order: the data in resource **2** of the migration-source volume, the data in resource **1** of the migration-source volume, and then the data in migration-destination resource **10**, and so on. The performance of the volume at the migration destination can therefore be calculated from the ratio of resources assigned at the migration destination and the media performance on the basis of the inferred result.

For example, the response performance can be calculated by multiplying the average performance of each resource by the ratio with which data is stored in a plurality of resources of varying performance in the migration-destination storage apparatus **1000***b*. More specifically, it is presumed that, in the migration-destination storage apparatus b, in a 1 TB (1024 GB) data amount, 20% of the data is stored on an SSD, 60% on an FC, and 20% on a SATA. It is also assumed that the average response performance of each resource is 1 (sec) for the SSD, 2 (sec) for the FC, and 3 (sec) for the SATA. In this case, the average response performance of the whole migration-destination storage apparatus **1000***b* is calculated by the following equation.

[Math 2]

$$1\times(20/100)+2\times(60/100)+3\times(20/100)=2.0\ (\text{sec}) \tag{2}$$

In addition, according to this embodiment, although acquiring IOPS information of each of all the segments from the storage apparatus **1000** enables the volume performance to be estimated highly accurately, the migration-destination volume performance prediction program **5114** is able to acquire more accurate IOPS statistical information by configuring the granularity of the statistical information more accurately in step S**4020**. Examples of a more precise configuration of the statistical information granularity is the number of segments with an IOPS of 0 to 1000 or the number of segments with an IOPS of 1001 to 2000, and so on. The migration-destination volume performance prediction program **5114** is accordingly able to adjust the data transfer amount and the accuracy of the statistical information.

Note that the time of the previous acquisition in step S**4020** may be transmitted to the statistical information creation program **1215** and the statistical information may be acquired only for points where the configuration has changed, since the previous acquisition time, within the range of the statistical information acquired from the statistical information creation program **1215** in step S**4030**. With this method, the amount of data transferred between the management computer **5000** and the storage apparatuses **1000** can be reduced further.

(4) Further Embodiments

Note that although, in the foregoing embodiments, the control device **5200** of the management computer **5000** implements the various functions of the backup capacity calculation unit, the migration-source data determination unit, the migration-destination storage apparatus determination unit and the data migration instruction unit and so on of the present invention on the basis of various programs stored in the management computer **5000**, but the embodiment is not limited to this example. For example, various functions may also be implemented in co-operation with the CPU by providing the control device **5200** in another apparatus separate from the management computer **5000**. Furthermore, the various functions may also be implemented by providing the various programs stored in the management computer **5000** in another apparatus separate from the management computer **5000** and as a result of the program being called by the control device **5200**.

Furthermore, each of the steps in the processing of the management computer **5000** of this specification need not necessarily be processed in chronological order according to the sequence presented in the flowchart. In other words, the steps in the processing of the management computer **5000** and the like may also be executed in parallel even if the processing is different.

In addition, hardware such as the CPU, ROM, and RAM contained in the management computer **5000** or the like can also be created in the form of computer programs for exhibiting the same functions as each of the foregoing configurations of the management computer **5000**. A storage medium storing these computer programs may also be provided.

INDUSTRIAL APPLICABILITY

The present invention can also be applied to a computer system for managing data migration of storage apparatuses, and to a management computer and storage management method.

REFERENCE SIGNS LIST

1000 Storage apparatus
1100 Disk device
1210 Main memory
1211 Configuration management program
1212 Storage physical and logical storage area mapping table
1213 Resource configuration table
1214 Storage external storage configuration table
1215 Statistical information creation program
1220 Control device
1230 Host I/F
1240 Management I/F
1250 Disk I/F
1260 External connection I/F
2000 Host computer
2100 Main memory
2200 Control device
2300 Host I/F
2400 Management I/F
3000 Data network
4000 Management network
5000 Management computer
5100 Main memory
5110 System management program
5112 Data migration required time computation program
5113 Statistical information acquisition program
5150 Resource management table
5155 Management external storage configuration table
5160 Management physical and logical storage area mapping table
5170 Disk type performance information table
5180 Port performance information table
5200 Control device
5300 Management I/F
6000 I/O apparatus

The invention claimed is:

1. A computer system comprising:

a plurality of storage apparatuses;

a plurality of host apparatuses configured to issue a data writing request to the plurality of storage apparatuses; and

a management computer configured to manage the plurality of storage apparatuses and the plurality of host apparatuses,

wherein the plurality of storage apparatuses, the plurality of host apparatuses, and the management computer are interconnected via a network,

wherein at least one storage apparatus of the plurality of storage apparatuses comprises:

a storage device which stores data which is read/written by at least one host apparatus of the plurality of host apparatuses; and

a control device configured to control the data writing to the storage device,

wherein the control device is configured to provide a predetermined storage area of the storage device to the host apparatus as one or more volumes and provide statistical information relating to the storage areas to the management computer in response to a request from the management computer,

wherein a volume of the one or more volumes is a virtual volume configured from different resources having different performances,

wherein the management computer comprises:

a storage device which stores a storage area management table which manages storage areas of the plurality of storage apparatuses, and

a control device configured to manage the configuration of the storage areas of the plurality of storage apparatuses,

wherein the control device of the management computer is configured to provide, to the storage apparatuses, volume units or pool units as units of the statistical information relating to the storage areas, and number of segments assigned for each resource as types and/or granularity of the statistical information or data occupancy in the volumes,

wherein the granularity of statistical information includes the number of segments assigned for each different resource,

wherein the control device of the at least one storage apparatus is configured to generate the statistical information relating to the storage areas based on the units, types and/or granularity of the statistical information relating to the storage areas provided to the management computer,

wherein the control device of the management computer is configured to calculate information relating to data configuration of the storage apparatuses based on the statistical information relating to the storage areas of the storage apparatuses and which is provided by the storage apparatuses,

wherein the control device of the at least one storage apparatus is configured to manage changes in configuration information and performance information of the storage areas of the storage device and provide, to the management computer, the statistical information relating to the storage areas based on an update in response to a request from the management computer, and

wherein the control device of the management computer is configured to manage the data configuration of the plurality of storage apparatuses by using the statistical information.

2. The computer system according to claim **1**, wherein the control device of the at least one storage apparatus is configured to assign an unassigned area among the storage areas to the data storage area of the volume in response to a write request by the host apparatus, and wherein the control device of the management computer is configured to manage the data configuration stored in the volume of the at least one storage apparatus.

3. The computer system according to claim **1**, wherein the control device of the at least one storage apparatus is configured to dynamically change assignment of the data stored in the volume to which the storage area is already assigned to the storage area of a different performance depending on the state of access to the data, and wherein the control device of the management computer is configured to manage the data configuration stored in the volume of the at least one storage apparatus.

4. The computer system according to claim **1**, wherein the control device of the management computer is configured to calculate a data migration required time when the data stored in the volume of the at least one storage apparatus is migrated to another volume on the basis of the statistical information relating to the storage areas of the at least one storage apparatus which is provided by the at least one storage apparatus.

5. The computer system according to claim **1**, wherein the control device of the management computer is configured to calculate the data access performance, when data stored in the volume of the at least one storage apparatus is migrated to another volume, of the other migration-destination volume, on the basis of the statistical information relating to the storage areas of the at least one storage apparatus provided by the at least one storage apparatus.

6. The computer system according to claim **1**, wherein the control device of the management computer is configured to manage the data configuration of the plurality of storage apparatuses on the basis of the statistical information, provided by the plurality of storage apparatuses, which relates to the storage areas of the plurality of storage apparatuses.

7. A management computer in which a plurality of storage apparatuses and a plurality of host apparatuses that issue a data writing request to the plurality of storage apparatuses are interconnected via a network,

wherein at least one storage apparatus of the plurality of storage apparatuses is configured to

provide a predetermined storage area of the at least one storage apparatus to a host apparatus of the plurality of host apparatuses as one or more volumes,

wherein a volume of the one or more volumes is a virtual volume configured from different resources having different performances,

manage changes in configuration information and performance information of storage areas of the at least one storage apparatus, and

provide statistical information relating to the storage areas based on an update to the management computer in response to a request from the management computer,

wherein the management computer comprises a storage device that stores a storage area management table for managing the storage area of the plurality of storage apparatuses and a control device configured to manage the configuration of the storage areas of the plurality of storage apparatuses, and wherein the control device is configured:

to provide, to the plurality of storage apparatuses, volume units or pool units as units of the statistical information relating to the storage areas, and number of segments assigned for each resource as types and/or granularity of the statistical information or data occupancy in the volumes,

wherein the granularity of statistical information includes the number of segments assigned for each different resource, and

to calculate information relating to data configuration of the storage apparatuses based on the statistical information relating to the storage areas of the storage apparatuses based on units, types and/or granularity of the statistical information relating to the storage areas and which is provided by the storage apparatuses, and

wherein the control device is configured to manage the data configuration of the plurality of storage apparatuses by using the statistical information.

8. A storage management method of a computer system in which a plurality of storage apparatuses, a plurality of host apparatuses which issue a data writing request to the plurality of storage apparatuses, and a management computer which manages the plurality of storage apparatuses and plurality of host apparatuses are interconnected via a network, comprising:

a first step in which at least one storage apparatus of the plurality of storage apparatuses provides a predetermined storage area of the at least one storage apparatus to a host apparatus of the plurality of host apparatuses as one or more volumes,

wherein a volume of the one or more volumes is a virtual volume configured from different resources having different performances;

a second step in which the management computer issues a request for statistical information relating to storage areas to the at least one storage apparatus;

a third step in which the at least one storage apparatus provides the statistical information relating to the storage areas to the management computer in response to the request from the management computer;

a fourth step in which the management computer manages data configuration of the plurality of storage apparatuses by using statistical information;

a fifth step in which the management computer provides, to the storage apparatuses, volume units or pool units as units of the statistical information relating to the storage areas, and number of segments assigned for each resource as types and/or granularity of the statistical information or data occupancy in the volumes,

wherein the granularity of statistical information includes the number of segments assigned for each different resource;

a sixth step in which the at least one storage apparatus generates the statistical information relating to the storage areas based on units, types and/or granularity of the statistical information relating to the storage areas provided to the management computer; and

a seventh step in which the management computer calculates information relating to the data configuration of the storage apparatuses based on the statistical information relating to the storage areas of the storage apparatuses and which is provided by the storage apparatuses, and

wherein the at least one storage apparatus manages changes in configuration information and performance information of the storage areas of the at least one storage apparatus and provide, to the management computer, the statistical information relating to the storage areas based on an update in response to a request from the management computer.

* * * * *